3. Biological Setting

The NWT Diamonds Project is located in the central portion of the Northwest Territories halfway between Great Slave and Great Bear lakes. Mine development will take place north of Lac de Gras in the tundra environment, approximately 200 km south of the Arctic Circle.

The NWT Diamonds Project is situated within the Southern Arctic Ecozone. This ecological classification refers to particular ecological characteristics as defined by Environment Canada and Agriculture Canada (Ecological Stratification Working Group 1995). Specifically, the project is within ecosection 41 of the Takijua Lake Upland Ecoregion (Figure 3-1).

The climate in the Lac de Gras area is extreme as summers are generally short and cool and winters are long and cold. Precipitation is sparse and consists of relatively equal portions of rain and snow. Winds are moderate and are predominately from the northwest.

Due to the harsh physiographic conditions, there has been little soil development in the Lac de Gras area. Most of the ground consists of permafrost. Small amounts of soil are found along the tops of eskers and around the shores of lakes adjacent to wetlands.

Severe climatic conditions and poor soil have resulted in relatively little vegetation. The project site is approximately 100 km north of the tree line. Vegetation is typically low in stature and dominated by lichens, mosses, herbs and low shrubs. Most plant species are perennial with low annual growth rates. Little aquatic vegetation is present.

The site of the NWT Diamonds Project provides habitat for a number of large and small mammals. The Bathurst caribou herd migrates through the area during spring and fall. Grizzly bears, wolves, wolverine, arctic fox and red fox forage and den in the area. Small mammals such as ground squirrels, arctic hares and snowshoe hares are important sources of food for the larger carnivores.

Bird populations are typically low in northern ecosystems due to the low productivity of suitable habitat. However, the ptarmigan inhabits the Lac de Gras area year-round, and migratory birds are expected to use most of the habitat types in this area for foraging and/or nesting, particularly during late summer. Raptors such as bald and golden eagles, owls and hawks have been sighted and nesting of peregrine falcons has been confirmed. Waterfowl and perching birds nest in areas of suitable habitat during spring and summer.

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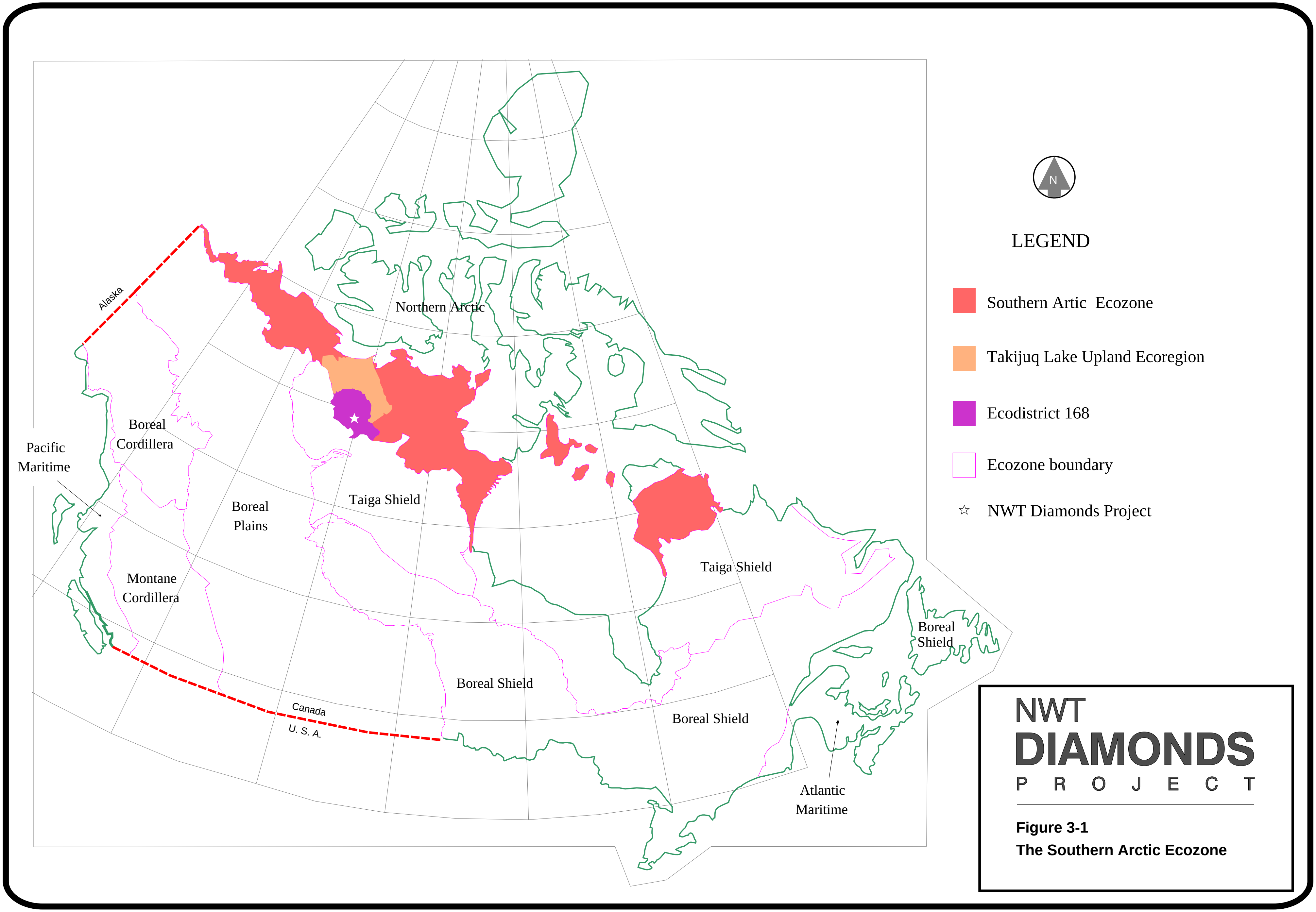

Figure 3-1
The Southern Arctic Ecozone

Source: Adapted from Ecological Stratification Working Group

Aquatic productivity is relatively low in arctic lakes. However, sufficient nutrients are present in lakes within the NWT Diamonds Project claim block to support the phytoplanktonic food base for populations of zooplankton and aquatic macroinvertebrates and to sustain viable fish populations. Fish species consist of lake trout, round whitefish, arctic grayling, slimy sculpin and longnose sucker.

The following sections discuss specific aspects of the existing biological environment. Specific components and processes are described in an ecosystem approach. This approach attempts to discuss the various elements (e.g., species) that comprise a specific component (e.g., wildlife) of an ecosystem, the relationships between various elements and components, and the processes that link them together.

Each of the biological setting sections explains what is currently known about each component so that any potential impacts to that component can be measured or predicted. Current baseline conditions have been compiled through reviews of existing literature as well as extensive field investigations since 1993. The field work was conducted according to NWT Diamonds Baseline Environmental Study Protocols (BHP 1993). Government officials and technical experts have been consulted throughout the evaluation of baseline conditions. This portrayal of baseline conditions will serve as a basis to predict any potential changes that may result from the development of the NWT Diamonds Project.

Since the discussion of ecosystems and ecosystem components tends to generate a substantial amount of information, this chapter will identify valued ecosystem components that will enable the reader to focus on specific valued aspects of ecosystems. Valued ecosystem components are “the environmental attributes or components identified as a result of a social scoping exercise as having scientific, social, cultural, economic or aesthetic value” (FEARO 1986). The ensuing discussion of potential impacts (Volume IV) will concentrate largely on these components.

3.1 Aquatic Life

This overview provides an outline of the three components in this section: the primary and secondary producers, and fish. It focuses on the biological aspects of freshwater, including both flora and fauna. The fundamental energy source in aquatic ecosystems is sunlight, which is fixed by the autotrophic component of the ecosystem, the algae, as primary production. The primary producers in streams are the periphyton, and in lakes the phytoplankton.

Stream periphyton comprise a complex community of microbiota (algae, bacteria, fungi, rotifers, nematodes, protozoans and detritus) which are loosely attached to submerged substrate (Wetzel 1983). Phytoplankton, minute suspended plants, inhabit the pelagic or open water region in lakes. The studies of periphyton and phytoplankton communities are a valuable component of stream and lake assessments, because changes in composition and abundance within communities can be accurate indicators of changes in water quality (Putnam 1994; Stevenson and Lowe 1986). Since animals and plants are interrelated in every community, a reduction in primary production may limit the growth and reproduction of other organisms that depend on algae as a source of energy (Fee *et al.* 1987; Moore 1978c).

The energy from primary production is available to the heterotrophic component of the ecosystem of which the herbivores (algae eaters) are the secondary producers. Organisms that feed on the primary producers, either directly as their prey or on their decomposing remains, are known as secondary producers. The algae are food for the smallest invertebrates, which, in turn, are food for the larger invertebrates and fish. The secondary producers in streams are the larval drift and benthic or bottom-dwelling invertebrates, and in lakes the zooplankton and benthic invertebrates.

Larval drift consists of invertebrates (primarily insects and worms) carried by stream currents. These drifting invertebrates become dissociated from their substrate (either actively or passively) and are transported downstream (Benke *et al.* 1991). Many of the fish fry that inhabit streams depend upon drifting invertebrates as their main source of food (Healey 1984).

Zooplankton are the minute aquatic and terrestrial organisms that constitute the animal portion of plankton in lakes. Drifting suspended in the water column, they are found most abundantly in pelagic lake habitat. The major taxonomic groups of zooplankton in freshwater lakes are Rotifera and Crustacea (Moss 1988). Most zooplankters graze upon phytoplankton, bacteria and detritus for food energy, although some of the carnivorous species feed upon smaller zooplankton. The larger zooplankters are vulnerable to predation by other invertebrates and are especially attractive to fish. Many fish species, including grayling, lake trout and whitefish, are dependent upon zooplankton as food at some stage in their life (Scott and Crossman 1973).

Benthos, a general term for invertebrate organisms living on, or in the bottom sediments, play several important roles in the aquatic community. As secondary producers in both lakes and streams, they mineralize and recycle organic matter created in the waters above or upstream, and in turn, become the main source of food for many fish species (EVS 1992; Wotton 1994; Lind 1979). Being composed of sedentary organisms of low mobility and relatively long life-span, the benthos closely reflect the benthic environment. Their sensitivity to both long and short term change provides an invaluable tool for assessing the effect and magnitude of change in water quality or sediment amount and composition. The larger benthic organisms, mostly insect larvae, dominate secondary productivity. Invertebrates occupy a key position in aquatic ecosystems, as grazers of algae and bacteria, and as major prey items for fish and birds (Thorp and Covich 1991). Any notable decrease in secondary producer density eventually affects fish populations.

Fish are an integral component of freshwater systems, as they form the last link in the aquatic food chain. Their impact in terms of energy flux and nutrient regeneration can be quite significant: fish can have marked effects on zooplanktonic and benthic composition and productivity, which influences the primary productivity.

The major species occurring frequently in the study lakes were lake trout (*Salvelinus namaycush*), round whitefish (*Prosopium cylindraceum*) and arctic grayling (*Thymallus arcticus*). Burbot (*Lota lota*), longnose sucker (*Catostomus catostomus*), slimy sculpin (*Cottus cognatus*) and lake chub (*Couesius plumbeus*) occur infrequently. The species compositions of the study lakes are characteristic of the region, with the exception of having no whitefish or cisco species. Lake trout and arctic grayling have been identified as valued ecosystem components. Lake trout is the dominant species in area lakes and is an important food fish in the region. Arctic grayling is the main species utilizing project area streams and is often sought by anglers elsewhere within its range.

The abundance, distribution, habitat use, life history characteristics (age, growth and condition), feeding habits and trace metal tissue analyses are discussed in detail in the fish section. A comparison of relative abundance of species and lakes was measured in terms of catch per unit effort (CPUE). The size of the population was estimated by using mark and recovery techniques. Habitat, which largely determines activities such as feeding and spawning, was evaluated in terms of climate, substrate and water quality. The age of a fish of given size was determined from scales, finrays and otoliths. Analysis of stomach contents provided an assessment of ecosystem relationships. Trace metal analysis documented background concentrations of metallic elements in fish tissues (dorsal muscle and liver tissue).

Baseline studies were conducted on lakes and streams in the Koala and adjacent watersheds during the ice-free periods of 1993 and 1994 to determine community structure of primary and secondary producers, and fish. Clear, cold, oligotrophic lakes, such as those found in these watersheds, are relatively impoverished in nutrients, especially nitrogen and phosphorus. Thus, naturally occurring chemical and physical factors may prevent primary producers from achieving their maximum growth rates; this, in turn, may limit the growth and reproduction of secondary producers and fish. Although densities of organisms may be high, small organisms may dominate and therefore overall biomass will be low.

3.1.1 Primary Producers

Primary producers in aquatic environments consist mainly of algae. The primary producers in streams are the periphyton and in lakes, the phytoplankton.

3.1.1.1 Stream Periphyton

Periphyton comprise a complex community of microbiota, which are loosely attached to substrata that may be inorganic, organic, living or dead (Wetzel 1983; Lind 1979). In the NWT, most stream beds consist of rocks, ranging in size from coarse gravel to large boulders, providing nearly unlimited surfaces upon which these organisms may grow. The objective of the 1994 baseline study was to collect algal periphyton growing on rocks (epilithon) to determine community composition and relative abundance. Three categories of periphyton comparison are presented below: relative abundance and diversity of epilithic classes; seasonal and annual comparisons; and comparisons with other arctic periphyton studies.

Previous Research

Few studies have been conducted on periphyton in the NWT. However, a study conducted by Moore (1979) included the assessment of periphyton in 21 lakes and streams between latitudes 62°N and 66°N. The closest stream site to the Koala watershed was at 65°38'N, 112°51'W, and is located within the Southern Arctic Ecozone. Sheath and Helleburst (1978) examined periphyton in a tundra pond (69°N latitude), and Bergmann and Welch (1990) studied periphyton in four small, shallow (<4 m depth) lakes located at Saqvaqjuac (63°N). Although these two studies were conducted in non-flowing systems, they share somewhat similar conditions with the Koala watershed due to latitude. The studies mentioned are compared to the results of 1993 and 1994 studies conducted in the Koala and adjacent watersheds.

Methods

A preliminary study on periphyton was conducted between August 12 to 14, 1993, on five stream sites: Koala-Kodiak, Moose-Nero, Larry-Nero, Airstrip-Larry and Nancy-Long. Periphyton was assessed three times during the ice-free period in 1994 (June 7 to 13, August 2 to 10 and September 11 to 19) at 19 sites. Fourteen of these sites were in the Koala watershed (Figure 2.4-1) and five in the surrounding watersheds (Figures 2.4-2 to 2.4-4). Fourteen streams were sampled in June (arctic springtime) immediately after the ice began to melt, ten streams in August (the mid-summer period) and eight streams in September (the fall period prior to freezing). Periphyton data for each site are presented in Appendix II-B1. The number of sampling sites decreased from spring to fall as stream flows became negligible and only subsurface flows occurred. At each site, a randomly selected area of colonized rock substrate was sampled *in situ* in <0.5 m of water using a combination syringe-brush to collect two composites (total area: 9.82 cm^2 of epilithon). The epilithic sample was then transferred to a 125 mL glass jar and preserved in Lugol's solution.

Periphyton analyses were carried out by Fraser Environmental Services in accordance with procedures set out in their methods manual (Looy 1994). Slides were prepared and scanned using a microscope at increasing powers of magnification to determine which genera were present. Components of the epilithon were identified to the genus level. A randomly removed sample volume (usually 25 mL) was transferred to a settling chamber and allowed to settle for approximately four hours. From each settling chamber, ten random fields were counted until a total of 100 individuals was obtained for the dominant genera. A total cell count (cells/mL) was obtained from these figures. Standing crop was calculated by dividing the number of cells counted by the sampling area (9.82 cm^2) and is expressed as cells/cm^2.

As biological data are seldom normally distributed about the mean, the data were transformed prior to statistical analysis (Appendix II-B1). A natural logarithm transformation of standing crop data was conducted (Stevenson and Lowe 1986; Green 1979). Arcsine transformations of the square root of the relative abundances (expressed as proportions) were also conducted. The phyla with abundances >0 in all samples and all phyla with a relative abundance >1% in any one sample were chosen for further statistical analysis.

Seasonal and annual variations were analyzed by means of *two-factor without replication analysis of variance* tests, or ANOVAs. Results were compared with the specified confidence level (95%) to determine possible significant differences in community composition or standing crop (Appendix II-B1).

Relative Abundance and Diversity

Eighty-one genera were identified from the epilithic community in the Koala and adjacent watersheds in 1994 (Table 3.1-1). Chlorophyta was the most diverse phylum, with 35 genera represented, followed by Bacillariophyta (26) and Cyanophyta (12). The major contributors to the 1994 average standing crop were Cyanophyta (56%), Bacillariophyta (40%) and Chlorophyta (3%) (Figure 3.1-1). The remaining standing crop (<1%) was represented by Chrysophyta, Euglenophyta, Pyrrophyta and Cryptophyta. Cyanophyta (blue-green algae) were most abundant in all samplings in 1994, whereas Bacillariophyta (diatoms) dominated the periphyton in August 1993 (Figure 3.1-1). *Tabellaria*, a diatom genus present and abundant in every stream during all 1993 and 1994 samplings, was also the dominant genus in a study that sampled 21 lakes and streams in the NWT between latitudes 62°N and 66°N (Moore 1979).

Table 3.1-1
Stream Periphyton Genera Identified
in 1993 (n=5) and 1994 (n=14)

Phylum	Order	Genera	Aug 93	Jun 94	Aug 94	Sep 94
Bacillariophyta	Centrales	*Cyclotella*		+	+	+
		Melosira	+	+	+	+
		Rhizosolenia		+		
	Pennales	*Achnanthes*	+	+	+	+
		Amphora			+	
		Anomoeoneis	+			
		Caloneis		+	+	
		Ceratoneis	+	+	+	+
		Cocconeis		+	+	+
		Cymatopleura			+	+
		Cymbella	+	+	+	+
		Diatoma	+		+	+
		Epithemia	+	+	+	+
		Eunotia	+	+	+	+
		Fragilaria	+	+	+	+
		Frustulia	+	+	+	+
		Gomphonema	+	+	+	+
		Navicula		+	+	+
		Nedium		+	+	
		Nitzschia		+	+	+
		Pinnularia		+		+
		Pleuro/Gyrosigma		+	+	+
		Rhopalodia			+	+
		Stauroneis		+	+	+
		Surirella		+	+	+
		Synedra	+	+	+	+
		Tabellaria	+	+	+	+
	Chaetophorales	*Draparnaldia*	+			
Chlorophyta	Chlorococcales	*Ankistrodesmus*	+	+	+	+
		Botryococcus		+	+	+
		Crucigenia			+	+
		Elakatothrix		+	+	+
		Nephrocytium		+	+	+
		Oocystis		+	+	+
		Pediastrum		+	+	+
		Quadrigula		+	+	+
		Scenedesmus	+	+	+	+
		Schroederia				+
Chlorophyta		*Sphaerocystis*		+	+	+
		Tetraedron		+		+
	Oedogoniales	*Bulbochaete*	+	+	+	+
		Oedogonium		+	+	+
	Tetrasporales	*Gloeocystis*		+	+	+
	Ulothricales	*Geminella*		+	+	+
		Stigeoclonium			+	

(continued)

Table 3.1-1 (completed)
Stream Periphyton Genera Identified
in 1993 (n=5) and 1994 (n=14)

Phylum	Order	Genera	Aug 93	Jun 94	Aug 94	Sep 94
		Ulothrix	+	+	+	+
	Uvales	*Shcizomeris*				+
	Volvocales	*Eudorina*			+	+
	Zygnematales	*Arthrodesmus*	+	+	+	+
		Bambusina		+		+
		Closterium	+	+	+	+
		Cosmarium	+	+	+	+
		Cylindrocystis		+	+	+
		Euastrum	+	+	+	+
		Gonatozygon			+	+
		Hyalotheca	+	+		+
		Mougeotia	+	+	+	+
		Netrium	+	+		+
		Spirogyra				+
		Spondylosium	+	+	+	+
		Staurastrum	+	+	+	+
		Xanthidium		+	+	+
		Zygnema	+	+	+	+
Chrysophyta	Chromulinales	*Hydrurus*		+		
	Ochromonadales	*Dinobryon*		+	+	+
		Mallomonas				+
Chrysophyta	Rhizochrysidales	*Diceras*			+	+
Cryptophyta	Cryptomonadales	*Chroomonas*		+		+
		Cryptomonas		+	+	+
Cyanophyta	Chroococcales	*Agmenellum*		+	+	+
		Anacystis		+	+	+
		Aphanocapsa	+			
		Aphanothece	+			
		Chroococcus	+			
		Coelosphaerium	+			
		Dactylococcopsis		+		
		Gloeacapsa	+			
Cyanophyta		*Gomphosphaeria*		+	+	+
		Merismopedia	+			
	Oscillatoriales	*Lyngbya*	+	+	+	+
		Oscillatoria	+	+	+	+
		Phormidium	+			+
		Schizothrix like	+			
	Nostocales	*Anabaena*	+	+	+	+
		Calothrix	+	+		
		Nostoc	+	+	+	+
		Rivularia	+	+	+	+
		Stigonema		+	+	+
		Tolypothrix	+			
Euglenophyta	Euglenales	*Euglena*		+	+	+
Pyrrophyta	Peridiniales	*Peridinium*		+	+	+
Rhodophyta	Bangiales	*Compsopogon*	+			

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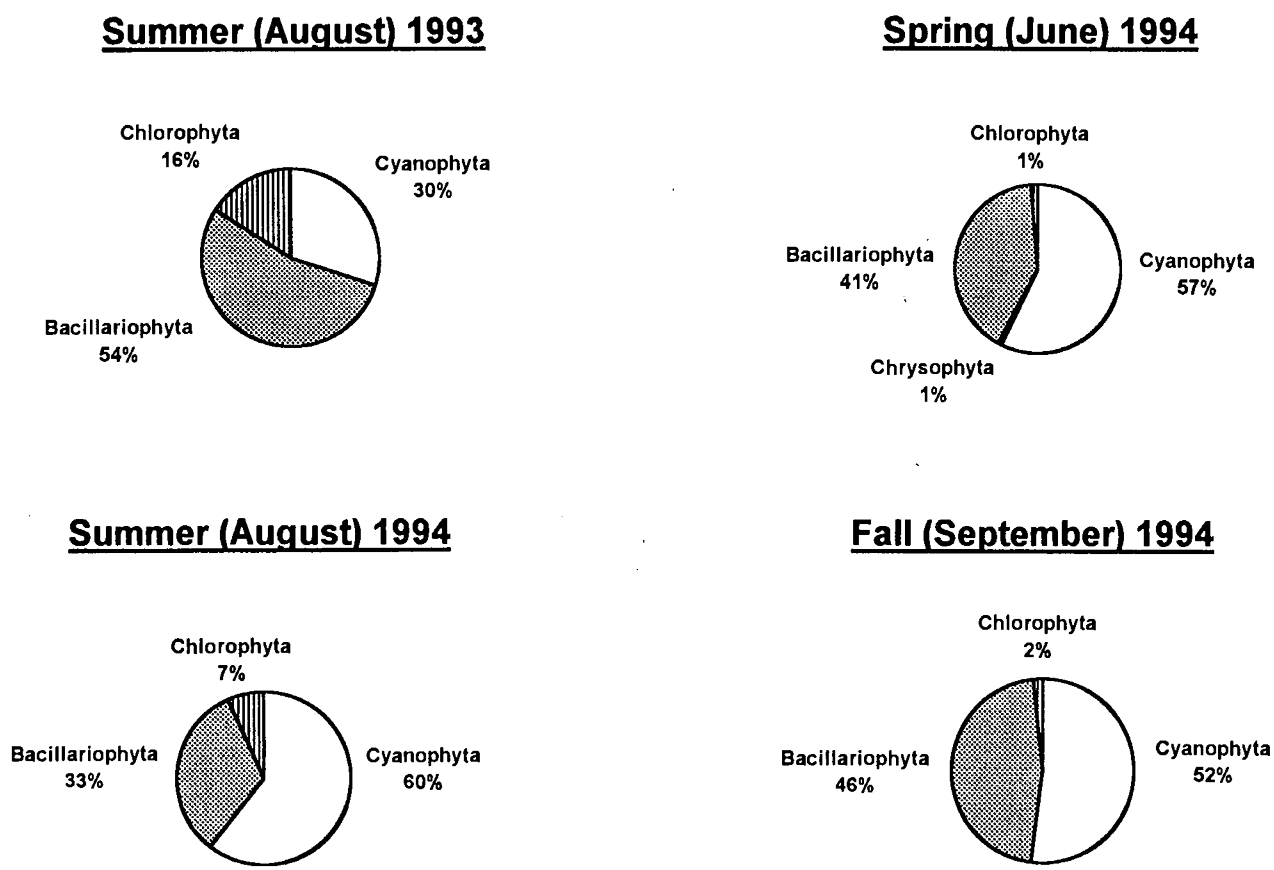


NWT DIAMONDS PROJECT

Figure 3.1-1
Seasonal Percent Composition of Stream Periphyton

Source: Rescan

Standing crops for the Koala and adjacent watersheds are presented on a seasonal basis as opposed to a site-by-site basis since sampling conditions were variable (i.e., the same rock was not sampled each time and stream depths and flows and other environmental conditions had changed). The mean seasonal standing crop was 0.69 x 10^6 cells/cm^2 in June, reached 2.68 x 10^6 cells/cm^2 during August and peaked in September at 5.24 x 10^6 cells/cm^2 (Table 3.1-2).

Table 3.1-2
Seasonal Standing Crops and Diversity Indices for Stream Periphyton

	Sampling Period			
	Summer 93	**Spring 94**	**Summer 94**	**Fall 94**
No. of Stream Sites Sampled	**5**	**14**	**14**	**8**
Standing Crop (10^6 cells/cm^2)	0.16	0.69	2.68	5.24
Diversity, H	2.41	1.60	1.96	1.66

Diversity is calculated by Shannon's Equation: H=-S P_i (lnP_i), where H is the diversity index and P_i is the proportion of individuals of the total sample belonging to the i^{th} genus.

Diversity indices reduce the bulk of survey data and aid in the interpretation of the results (Hellawell 1986). Diversity is a measure of both the number of taxa present (standing crop) and the uniformity with which the taxa are distributed (Kaesler *et al*. 1978). To quantify diversity for purposes of community comparisons, the Shannon Index was calculated for each sampling period (Hellawell 1986; Lind 1979). Undisturbed natural communities are assumed to have a high diversity, with no species having disproportionately large numbers of individuals (Lind 1979).

Based on the enumerated genera only, diversities for the 1994 samplings increased from spring to summer then decreased in fall. August 1993 showed the highest diversity index of all sampling periods (Table 3.1-2) as this community was most evenly distributed amongst the different genera.

Seasonal and Annual Comparisons for Community Composition and Standing Crop

Phylum abundances were compared to determine differences in standing crops for the two sampling seasons, and relative abundances were compared to emphasize differences in community composition (Stevenson and Lowe 1986). T-tests (two-sample assuming equal variances) were conducted to test the mean standing crop between streams in the Koala watershed and streams in the surrounding watersheds. The hypotheses tested were considered significant if $T > T_{crit}$.

Significant differences in seasonal or annual standing crops were observed. There were no significant annual and seasonal variations in algal phyla, indicating that community composition remained relatively constant. Standing crops were compared for the 1994 seasons between streams in the Koala watershed and adjacent streams and no significant differences were observed.

Factors Affecting Diversity and Standing Crop

An increase in standing crop from late August to early September may be attributed to higher nutrient concentrations that result from water evaporation throughout the summer (Sheath and Hellebust 1978), or increased availability of nutrients as a result of grazing (Otto 1983). While the standing crop of diatoms increased from spring to fall, the percentage composition decreased (Figure 3.1-1), which may be attributed to the fact that they are a more desirable food item for consumers than either green or blue-green algae (Moore 1978c, 1981). The increase in standing crop as the summer season progressed may be a result of decreased flows (Lloyd *et al.* 1987; BC MELP and UVIC 1992).

3.1.1.2 Phytoplankton

The purpose of the baseline study was to determine the characteristics of phytoplankton communities in the study lakes, including taxonomic composition, standing crop and diversity, and to relate them to environmental influences such as physical, chemical and biological factors.

Biological lake habitats may be divided into two main categories: pelagic and benthic. A pelagic habitat is one which has open water with sufficient depth and area that is not influenced by the lake bottom or shore and is inhabited mainly by minute suspended plants and animals (plankton). The actual extent of the primary production is largely determined by conditions in the upper pelagic region.

The study of phytoplankton communities is a valuable component of a water quality assessment because changes in composition and abundance within communities can be very accurate indicators of changes in water quality, (Putnam 1994; Stevenson and Lowe 1986). Therefore, changes observed among the producers (plants) will be reflected by the consumers (animals).

Previous Research

Several relevant phytoplankton studies have been conducted in subarctic lakes in the past. Welch *et al.* (1989) studied oligotrophic lakes to the east of the Koala watershed at Saqvaqjuac (63°N). Newcombe and MacDonald (1991) and Lloyd *et al.* (1987) studied the effects of light availability and turbidity in Alaskan lakes. Fee *et al.* (1987) conducted studies in lakes located in subarctic and arctic temperate zones between latitudes 57°N and 63°N. An extensive study by Moore (1978b) examined the distribution and abundance of phytoplankton species in 153 lakes, rivers and pools in the NWT. The closest lake to the Koala watershed was Mathews Lake, approximately 85 km southeast. The studies mentioned are compared to the results of 1993 and 1994 studies conducted in the Koala watershed.

Methods

A preliminary study on phytoplankton was conducted between August 7 and 13, 1993 on five lakes: Koala, Kodiak, Fox 1, Long and Panda (Figure 2.4-1). In 1994, the study was expanded to include Little, Leslie and Misery lakes (Figures 2.4-1 and 2.4-4). One sampling site was chosen in each lake, except Long Lake, which had two sites ("north" and "south"). There were two sampling periods during the 1994 ice-free period: June 28 to August 5 (subarctic spring to early summer) and August 12 to September 8 (subarctic late summer to fall). During each sampling period, a sample of surface water (1 m depth) was collected from the central portion of the pelagic region over the deepest part of each lake. A 5 L Go-Flo water sampling bottle was used for collection; a portion of that sample was immediately transferred to a 500 mL bottle and preserved with approximately 2 mL of Lugol's solution. Water transparency was measured at each site with a Secchi disc that was lowered vertically in the water until it could no longer be seen.

Phytoplankton analyses were conducted by Fraser Environmental Services in accordance with procedures set out in their methods manual (Looy 1994). Raw phytoplankton data are included in Appendix II-B2.

Taxonomic Composition

From 20 samples collected in 1993 and 1994, 70 genera were identified as belonging to the following phyla: Chlorophyta, Chrysophyta, Cyanophyta, Bacillariophyta, Cryptophyta and Pyrrophyta (Table 3.1-3). The greatest number of genera were identified in the Chlorophyta (29), followed by Bacillariophyta (21) and Cyanophyta (12). The number of genera per lake was generally highest in the 1993 sampling period (Table 3.1-4). Seasonal and annual comparisons are based on averages among the four lakes sampled during all three sampling periods: Koala, Kodiak, Long (South) and Fox 1. Of these three periods, the greatest number of genera was present in August to September 1994 (Table 3.1-4).

Standing Crop

In August (mid-summer) 1993, chrysophytes (golden brown algae) were most abundant, on average accounting for 96% of the community standing crop (Figures 3.1-2 and 3.1-3). Seasonal community compositions were different in Koala, Little, Long (S), Leslie and Misery lakes (Figure 3.1-2). Koala and Misery lakes were dominated by cryptophytes in late summer. In July (early summer),

Table 3.1-3
Phytoplankton Genera Identified
in 1993 (n=5) and 1994 (n=8)

Phylum	Order	Genera	Summer Aug 93	Early Summer Jun-Jul 94	Late Summer Aug-Sep 94
Cyanophyta	Chroococcales	***Agmenellum*** [(1)]		+	+
		Anacystis	+	+	+
		Aphanocapsa	+		
		Aphanothece	+		
		Coelosphaerium	+		
		Gloeocapsa	+		
		Gomphosphaeria		+	+
		Dactylococcopsis		+	
		Merismopedia	+		
		Microcystis	+		
	Nostocales	*Anabaena*	+	+	+
	Oscillatoriales	*Lyngbya*		+	+
Chrysophyta	Ochromonadales	***Dinobryon***	+	+	+
		Ochromonas	+		
		Mallomonas	+	+	
	Rhizochrysidales	***Diceras***		+	+
Bacillariophyta	Centrales	***Cyclotella***	+	+	+
		Melosira	+	+	+
		Rhizosolenia		+	+
	Pennales	*Achnanthes*		+	+
		Asterionella	+	+	
		Ceratoneis		+	+
		Cocconeis		+	
		Cymatopleura		+	
		Cymbella		+	+
		Diatoma			+
		Eunotia		+	+
		Fragilaria		+	+
		Frustulia	+	+	+
		Gomphonema		+	+
		Navicula		+	+
		Nitzschia		+	+
		Pleuro/Gyrosigma		+	+
		Stauroneis	+		
		Surirella			+
		Synedra	+	+	+
		Tabellaria	+	+	+
Cryptophyta	Cryptomonadales	*Chroomonas*	+	+	+
		Cryptomonas	+	+	+
Chlorophyta	Chlorococcales	*Ankistrodesmus*	+	+	+

(continued)

Table 3.1-3 (completed)
Phytoplankton Genera Identified
in 1993 (n=5) and 1994 (n=8)

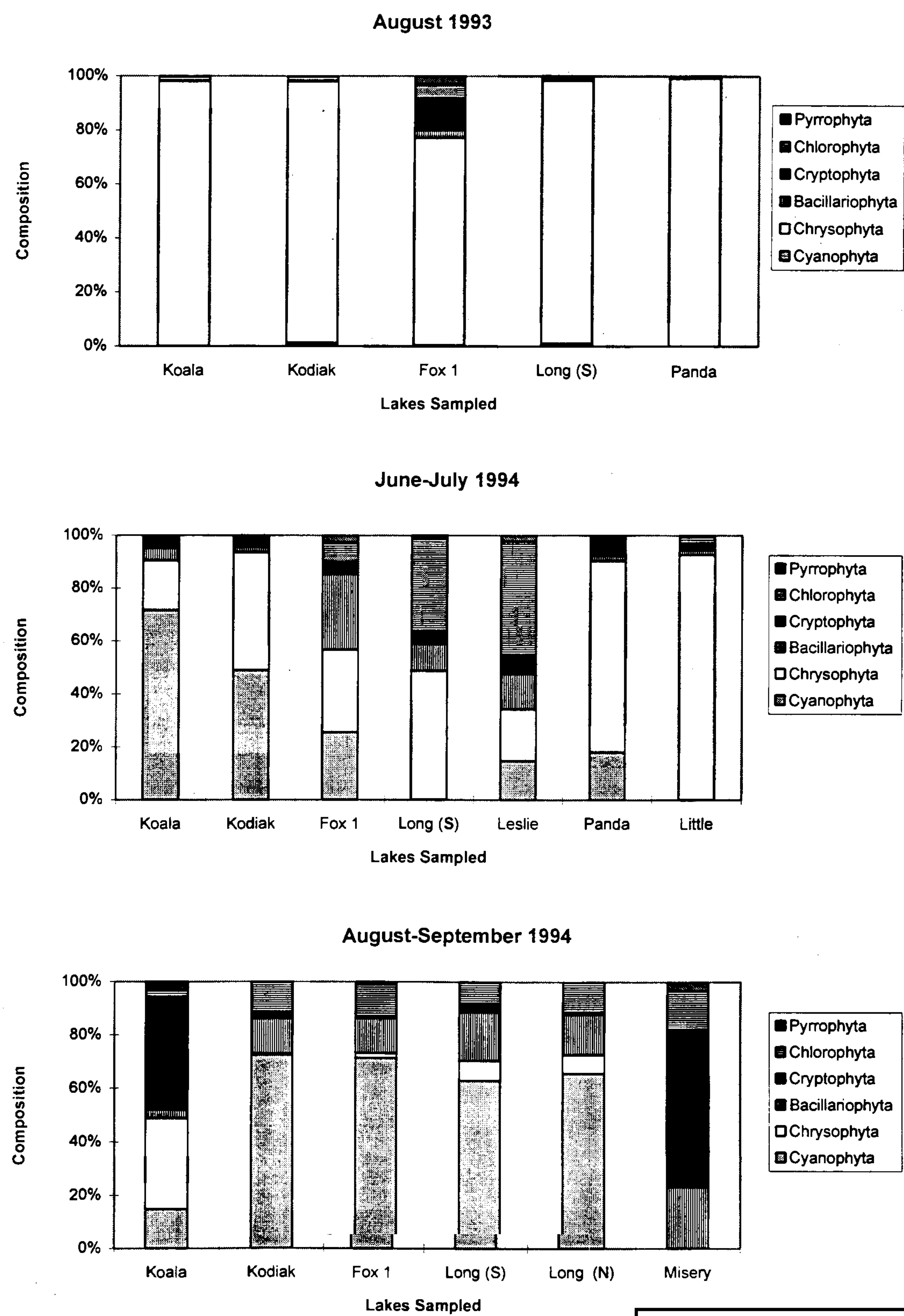
Phylum	Order	Genera	Summer Aug 93	Early Summer Jun-Jul 94	Late Summer Aug-Sep 94
		Botryococcus		+	+
		Crucigenia	+	+	+
		Dictyosphaerium		+	+
		Elakatothrix	+	+	+
		Nephrocytium		+	+
		Oocystis	+	+	+
		Quadrigula	+	+	+
		Schroederia			+
		Scenedesmus	+		+
		Selenastrum		+	+
		Sphaerocystis		+	+
		Tetraedron		+	+
	Tetrasporales	*Gloeocystis*	+	+	+
	Ulotrichales	*Geminella*			+
		Ulothrix		+	+
	Ulvales	*Schizomeris*			+
	Volvocales	*Chlamydomonas*			+
		Eudorina			+
	Zygnematales	*Arthrodesmus*	+	+	+
		Closterium		+	+
		Cosmarium	+	+	+
		Euastrum	+	+	+
		Gonatozygon			+
		Hyalotheca			
		Mougeotia	+		+
		Spondylosium	+	+	+
		Staurastrum		+	+
		Xanthidium		+	+
Pyrrophyta	Peridiniales	*Peridinium*		+	+
		Gymnodinium	+		

1: Genus bold type indicates oligotrophic indicator genera (Hutchison 1967).

Table 3.1-4
Number of Genera Identified, Standing Crop and Diversity for Each Lake Sampled for Phytoplankton

	Sample Period	Koala	Kodiak	Fox 1	Long (S) [1]	Long (N) [2]	Panda	Leslie	Little	Misery
Number of Genera	Aug 1993	19	22	13	25	23	21	n/s[3]	n/s	n/s
	Jun/Jul 1994	8	10	15	12	n/s	17	13	9	n/s
	Aug/Sep 1994	7	20	14	11	13	n/s	n/s	20	6
Standing Crop	Aug 1993	2.09	2.32	0.77	4.05	2.40	2.51	n/s	n/s	n/s
($x\ 10^9$ cells/m^3)	Jun /Jul 1994	0.41	1.31	1.43	0.28	n/s	1.71	0.23	0.61	n/s
	Aug./Sep. 1994	0.34	2.53	1.52	1.16	0.94	n/s	n/s	2.38	0.16
Diversity, H[4]	Aug 1993	0.82	0.65	0.90	0.26	0.84	0.85	n/s	n/s	n/s
	Jun /Jul 1994	0.94	1.46	2.03	1.79	n/s	1.15	2.22	0.50	n/s
	Aug/Sep 1994	1.53	1.93	1.24	1.90	1.84	n/s	n/s	2.11	1.26

1. S: South.
2. N: North.
3. n/s = not sampled.
4. Diversity is calculated by Shannon's equation: $H = -\Sigma P_i (\ln P_i)$. H is the diversity index and P_i is the proportion of individuals of the total sample belonging to the i^{th} genus. Only the first four lakes were sampled during all periods.



NWT DIAMONDS PROJECT

Figure 3.1-2
Percent Composition of Phytoplankton Phyla

Source: Rescan

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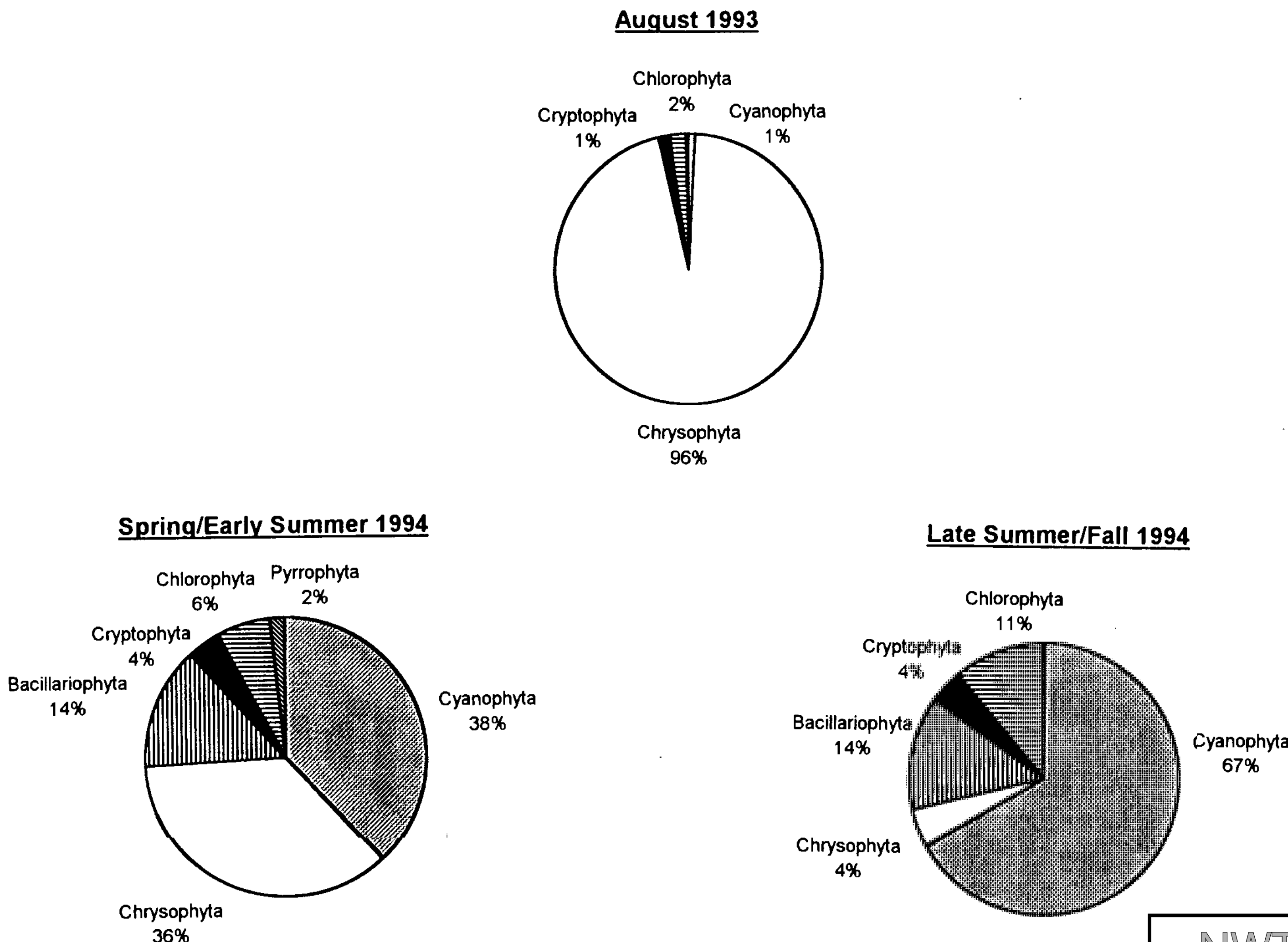

NWT DIAMONDS PROJECT

Figure 3.1-3
Percent Composition of Phytoplankton for Four Lakes

Source: Rescan

the communities of Leslie and Long lakes consisted of chrysophytes and chlorophytes (green algae). Little Lake was primarily dominated by chrysophytes in July.

Although some variability in standing crop did exist among lakes in 1994, chrysophytes and cyanophytes were particularly abundant in the early summer, representing 36% and 38% of the flora, respectively. Cyanophytes (blue-green algae) achieved dominance in late summer, accounting for 67% of the community (Figure 3.1-3). The average contribution of blue-green algae to the phytoplankton community increased 29% over the 1994 sampling period (Figure 3.1-3). The green algae also increased as the summer season progressed. Bacillariophytes (diatoms) and cryptophytes remained constant in both 1994 sample periods, while chrysophytes declined in late summer/fall. A "successional" change within algal communities takes place each season as the communities are reformed (Reynolds 1984).

In August 1993, the average algal standing crop was 2.31 x 10^9 cells/m^3, while in 1994 it was 0.86 x 10^9 cells/m^3 in early summer and increased to 1.39 x 10^9 cells/m^3 in late summer (Table 3.1-5). The limited growing season of lakes at high latitudes is reflected in a conspicuous single season summer maximum of phytoplankton standing crop.

Table 3.1-5
Mean Number of Genera, Standing Crop and Diversity for Phytoplankton Collected from Koala, Kodiak, Long(S) and Fox 1 Lakes

		Sampling Period	
	Aug 93	**Jun to Jul 94**	**Aug to Sep 94**
Number of Genera	31	46	50
Standing Crop (x 10^9 cells/m^3)	2.31	0.86	1.39
Diversity, H[1]	0.75	2.26	2.15

1: Diversity is calculated by Shannon's equation: $H = -\sum P_i (\ln P_i)$, where H is the diversity index and P_i is the proportion of individuals of the total sample belonging to the i^{th} genus.

In June/July 1994, *Dinobryon* was the most abundant (0.40 x 10^9 cells/m^3 to 12.32 x 10^9 cells/m^3) and widespread genus occurring in all lakes sampled. In August/September, *Lyngbya*, a blue-green alga, was the most abundant genus (0.51 x 10^9 cells/m^3 to 10.58 x 10^9 cells/m^3) at all sites except Misery Lake. Several diatoms were recorded, the most common being *Tabellaria* and *Cyclotella*. The Chlorophyta, particularly *Ankistrodesmus*, was present in all samples, but always in low numbers (0.03 x 10^9 cells/m^3 to 0.80 x 10^9 cells/m^3). Pyrrophyta were rare; the only genus identified in 1993 was *Gymnodinium* and in 1994, *Peridinium.*

These results were similar to those from studies conducted in oligotrophic lakes at Saqvaqjuac, NWT (Welch *et al.* 1989). Chlorophyta had low biomass but high diversity. In contrast, Cyanophyta had very low biomass throughout their study.

In 1978, extensive phytoplankton studies were conducted in NWT lakes. The closest lake to the Koala watershed was Mathews Lake, 85 m southeast (Moore 1978b). The results of these seasonal comparisons were remarkably similar considering the interval between samplings (Table 3.1-6).

Table 3.1-6
Mean Standing Crop
for the Most Abundant Phytoplankton in
Mathews Lake (1978) and the Koala Watershed (1994)

	Mean Standing Crop			
Date	**Mathews Lake (1978)**		**Koala Watershed (1994)[1]**	
June	*Diatoma tenue*	$4.8 \times 10^7/m^3$	Diatom spp.[2]	$5.3 \times 10^7/m^3$
August	*Dinobyron* spp.[3]	$5.5 \times 10^7/m^3$	*Dinobryon*	$7.5 \times 10^7/m^3$

1: Lakes sampled in June and August were used to obtain standing crop averages.
2: Average standing crop of the most abundant diatom in each of the seven lakes sampled.
3: Sum of *Dinobryon cylindricum* and *Dinobryon borgei* standing crops.

Diversity

Diversity was greatest in early summer when individuals belonged to different genera and lowest in late summer when all individuals belonged primarily to one genus. Diversity was much lower in 1993 as fewer taxa were present, while abundances were higher (Table 3.1-5). A comparison of each lake over time (Table 3.1-4) revealed that diversity was highest in August to September 1994 for all sites except Fox 1.

Temporal Variations

Phylum abundances were compared to determine differences in standing crops between sampling periods and relative abundances were compared to emphasize differences in community composition (Stevenson and Lowe 1986). Seasonal and annual variations were analyzed by means of *two-factor without replication analysis of variance* tests, or ANOVAs, at a 95% confidence level.

Comparisons of community taxonomic composition and standing crop, both within and among lakes over time, revealed no significant differences in algal compositions or standing crops, except among lake standing crops sampled in early summer 1994 (Table 3.1-7). Seasonal and annual comparisons based on the four lakes sampled (Koala, Kodiak, Long (N), Fox 1) during all three periods showed no significant differences in composition or standing crop.

Table 3.1-7
ANOVAs to Determine Significant Differences in Phytoplankton Community Composition and Standing Crop

Null	Hypothesis	Tested for	*F*	*Fcrit*	Result
No significant difference in community composition...	among lakes for each sampling period	Aug 93	0.37	2.60	accept
		Jun/Jul 94	0.82	2.42	accept
		Aug/Sept 94	0.02	2.42	accept
	within a site over time	Koala	0.11	4.10	accept
		Kodiak	0.03	4.10	accept
		Long (S)	0.05	4.10	accept
		Fox1	0.06	4.10	accept
	between Jul 94 and Aug 94	seasonal differences	0.05	6.61	accept
	between Aug 93 and Aug 94	annual differences	0.05	6.61	accept
No significant difference in standing crop...	among lakes for each sampling period	Aug 93	0.64	2.60	accept
		Jun/Jul 94	2.90	2.42	**REJECT**
		Aug/Sept 94	1.60	2.42	accept
	within a site over time	Koala	0.46	4.10	accept
		Kodiak	1.10	4.10	accept
		Long (S)	0.76	4.10	accept
		Fox1	1.04	4.10	accept
	between Jul 94 and Aug 94	seasonal differences	0.04	6.61	accept
	between Aug 93 and Aug 94	annual differences	0.70	6.61	accept

1: If $F > Fcrit$, then the null hypothesis is rejected.

Physical, Chemical and Biological Factors

Environmental conditions within each season cause different responses among phytoplankton populations. Even within each lake, phytoplankton may belong to separate water parcels with quite different characteristics. Populations fluctuate with time of day sampled, wind speed, water temperature, light intensity, nutrient availability and grazing pressures (Maitland 1990; Smith 1974).

Oligotrophic lakes, with characteristics similar to those in the Koala watershed, have algal communities typically consisting of diatoms (e.g., *Cyclotella*, *Tabellaria*), Chlorophyta (e.g., *Staurastrum*, *Oocystis*) and Chrysophyta (e.g., *Dinobryon*), while eutrophic lakes are characterized typically by blue-green algae (e.g., *Anabaena*, *Scenedesmus*), diatoms and green algae (Maitland 1990; Hellawell 1986; Wetzel 1975). Oligotrophic indicator genera are highlighted in Table 3.1-3 (Hutchinson 1967).

Inconsistent patterns found in lake-by-lake comparisons in June/July 1994 sampling indicate the complexity of the physiological responses to environmental influences exhibited by algal populations. The physical, chemical and biological conditions in the lakes varied considerably from lake to lake over the three sampling periods (Table 3.1-8) and are discussed separately below.

Physical Factors

The ecological effects of light and temperature on the photosynthesis and growth of algae are inseparable because of the interrelationships in metabolism and light saturation (Wetzel 1979). Water temperatures were low on the average, ranging from 9.4°C to 15.4°C (Table 3.1-8). As the water temperatures increased during the brief period when the lakes were not frozen, adaptation to higher illumination probably occurred (Wetzel 1979; Kalff and Welch 1974). After loss of ice cover in the summer, algae of arctic lakes are severely inhibited by high light intensities and remain deeper in the water column (Wetzel 1979). Therefore, the bulk of the phytoplankton is most likely below the 1 m sampling depth in the spring, which explains the apparent increase in standing crops later in the season. The blue-green algae are generally much more tolerant of higher temperatures than other algae (Wetzel 1979), which may explain their abundance in surface water sampled in August/September. Often by mid-summer, when surface temperatures are the warmest, blue-green algae with efficient capabilities for fixing molecular nitrogen have a competitive advantage and tend to dominate (Wetzel 1979) as seen in 1994. As the summer progressed, blue-green algae became more abundant, displacing the chrysophytes.

Water transparency revealed that the lakes were generally clearer in the latter part of summer. Turbidity is an important variable when considering water quality and algal growth, as it is likely to adversely affect light penetration (Newcombe

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Table 3.1-8
Physical, Chemical and Biological Characteristics of Surface Waters for Four Lakes in the Koala Watershed

Parameter	Koala Aug 93	Koala Jul 94	Koala Aug 94	Kodiak Aug 93	Kodiak Jul 94	Kodiak Aug 94	Long (S) Aug 93	Long (S) Jul 94	Long (S) Aug 94	Fox 1 Aug 93	Fox 1 Jul 94	Fox 1 Aug 94
Physical												
Temperature, °C	14.9	13.8	13.6	13.5	13.6	13.5	13.5	15.3	10.7	14.5	15.4	9.4
Secchi depth, m	2.8	1.0	2.0	4.5	2.0	4.0	8.0	8.0	6.0	1.8	5	5.5
Chemical												
pH	6.1	5.95	6.33	6.18	5.5	6.53	6.30	6.47	6.49	6.5	6.55	6.60
Total Phosphorus (P), mg/L	6	26	16	5	15	8	4	4	3	10	9	4
Nitrate (NO_3N), mg/L	22	5	5	5	5	5	5	5	5	5	5	45
N:P ratio	3.67	0.19	0.31	1.00	0.33	0.63	1.25	1.25	1.67	0.50	0.56	11.25
Biological												
Chlorophyll *a* , mg/L	0.73	0.11	0.71	1.11	0.41	0.67	0.63	0.33	0.04	0.95	0.28	0.5
Phytoplankton (x 10^9 cells/m^3)	2.09	0.41	0.34	2.32	1.31	2.53	4.05	0.28	1.16	0.77	1.43	1.52

and MacDonald 1991; Lloyd *et al.* 1987) and limits the abundance of phytoplankton even when sufficient nutrients are available (McCoy 1983; Lloyd *et al.* 1987). The baseline study showed low Secchi depths corresponded to low surface standing crops in all three sampling periods (Table 3.1-8).

Chemical Factors

Chemical analyses (sampling methodology is discussed in Section 2.4) showed considerable variation in concentrations among the four lakes (Table 3.1-8). Except for Koala Lake, the lakes had total phosphorus concentrations ranging from 2 µg/L to 9 µg/L and nitrate values generally averaging 5 µg/L. According to Dillon and Rigler's (1975) criteria, lakes may be ranked using three indicators of trophic status: total phosphorus, chlorophyll *a* and Secchi depth. Based on the range in total phosphorus concentrations (2 µg/L to 9 µg/L), average chlorophyll *a* levels (0.04 µg/L to 1.11 µg/L) and average phytoplankton numbers (0.34×10^7 cells/m^3 to 4.05×10^7 cells/m^3), the lakes are oligotrophic. Oligotrophic lakes are characterized by high diversity as observed in the 1994 samplings, i.e., many species of low standing crop (Hellawell 1986).

Phosphorus is typically the nutrient that limits primary production in northern temperate freshwater lakes; therefore, it controls summer phytoplankton production (McCoy 1983; Lloyd *et al.* 1987; Dillon and Rigler 1975). In arctic and subarctic environments, *Dinobryon* usually grows well for one to two months during the summer when warm temperatures and nutrients prevail (Moore 1978b). This may explain the dominance of *Dinobryon* in June to July in all the lakes sampled and its subsequent decline in late summer as temperatures and nutrients decrease.

Biological Factors

Chlorophyll *a*, a photosynthetic pigment present in algae, provides estimates of primary productivity. Low Secchi readings generally indicate low light penetration and low primary productivity, whereas high transparency and low chlorophyll *a* indicate that the algae are nutrient and not light limited (Fee *et al.* 1987). In all lakes, the lowest Secchi readings (Table 3.1-8) correspond with the lowest chlorophyll *a* values at all sites; these occurred in the early summer sampling. However, the high turbidity at this time indicates that primary production is light-limited.

Phytoplankton can control their depth in the water column to some extent. Algae that have this ability usually migrate downward in the water column with increasing light intensities to a better nutrient environment and light climate and ascend in the afternoon and evening (Carrick *et al.* 1993; Wetzel 1979; Kalff and Welch 1974). Photosynthesis is reduced near the surface during the midday hours as a result of light saturation, photoinhibition and downward migration. The structure of surface water communities may become altered within brief time frames (hours to days); this process can account for some of the temporal variation seen in the phytoplankton in the lakes and thus enhance temporal heterogeneity (Fee *et al.* 1987; Carrick *et al.* 1993). Consequently, short term variation, as well as seasonal variation in phytoplankton biomass, may be considerable.

Predation of phytoplankton by animals, particularly crustaceans, is often a significant factor in the decline of algal populations and contributes to seasonal succession. A degree of size and species selectivity also exists among the grazers. Such selectivity can lead to a competitive advantage for less effectively grazed species, thus influencing seasonal succession of algae within prevailing physical and nutrient constraints. Higher invertebrates and fish possessing size-selective feeding habits with respect to zooplankton, may influence zooplankton grazing effectiveness and, in turn, the algal succession. Grazing pressure and enhancement of the nutrient cycling rate may influence competition among the various algal species (Wetzel 1979).

Summary

The oligotrophic lakes and streams in the Koala and Misery watersheds have algal communities typically consisting of diatoms, chlorophytes, chrysophytes and cyanophytes. Increased standing crop and diversity were observed in lakes and streams in late summer as temperature and light became more favourable for growth.

3.1.2 Secondary Producers

The secondary producers in streams are the larval drift and bottom-dwelling invertebrates, and in lakes the zooplankton and benthic invertebrates.

3.1.2.1 Larval Drift

Larval drift consists of invertebrates (primarily insects and worms) that are carried by stream or river currents. Drifting insects, many of which spend their adult lives on land, are in their aquatic stages of development. However, larvae, pupae and adult stages of beetles, fish or other fauna that are exclusively aquatic are also found. These drifting invertebrates have become dissociated from their substrate (either actively or passively) and are transported for distances usually <10 m (Benke *et al.* 1991). Once in the current, they often attempt to colonize downstream habitat, but may be encountered first by predatory fish. Many of the fry that inhabit streams depend upon drifting invertebrates as their main source of food (Healey 1984). Thus, any notable decrease in invertebrate density eventually affects fish populations.

Changes in the biotic and abiotic factors of the stream will often affect invertebrate populations, though not always in a predictable manner. For example, studies have reported higher overall densities of certain species of aquatic insects after an unnatural increase in sediment load in streams (Wiederholm 1984). It is, therefore, important to monitor the abundance and diversity of drifting animals in order to understand the consequences of habitat changes and to assist in determining whether the local fish population has an adequate food supply.

Previous Research

Several northern invertebrate studies had results comparable to the study in the Koala region (64°40'N 110°34'W). For example, a study conducted in the NWT at Caribou-Poker Creek (65°08'N 147°28'W) found the stream dominated by dipterans (Miller and Stout 1989). Another extensive study done at Stanwell-Fletcher Lake (72°38'N 94°18'W), found that Chironomidae, a dipteran family, was the dominant taxon found in drift samples (de March *et al.* 1977). While these sites do not lie in the Southern Arctic ecozone, they were all conducted in the NWT in somewhat similar climatic conditions as the Koala and adjacent watersheds.

Methods

A total of 17 stream sites in the Koala, Ursula and South watersheds were sampled for larval drift in 1994 (Figures 2.4-1, 2.4-2 and 2.4-4). Fifteen were studied from June 10 to 19, twelve from August 3 to 11, and ten from September 12 to 21. The number of sampling sites decreased from spring to fall as flows in some streams became negligible. The seasonal larval drift data collected at each site are listed in Appendix II-B3. Samples were collected using a drift-net sampler, which consisted of a conical 500 µm or 1,000 µm mesh net with a removable cod-end, attached to a 0.16 m^2 frame. The sampler was secured with the net opening facing upstream in a suitable location in the centre of the stream (e.g., the tail end of a run or the top end of a riffle) with the bottom of the frame flush against the substrate and the top of the frame above the water surface. A soak time of 24 hours or more was allowed for most of the sites. The sample was transferred from the cod end of the net to a 500 mL jar and preserved in 10% buffered formalin. For comparative purposes, all values are expressed as numbers of organisms caught within a 24-hour period.

Larval drift analyses were performed by Applied Technical Services in Saanichton, B.C. Samples were rinsed with water through 163 µm and 333 µm mesh sieves to remove the preservative and obtain two size fractions. From each fraction, organisms were counted and stored by major taxonomic groups (i.e., chironomids, oligochaetes, etc.). If large numbers of organisms of a particular type were present, the sample was sub-sampled by weight until a reasonable number of that group was counted (approximately 200). When all the samples had been sorted in the above manner, the organisms were identified to species level, where possible and enumerated.

Two-way without replication analyses of variance (ANOVAs) were conducted using the 95% confidence level to determine whether there were significant differences among the seven sites and among sampling periods. Abundance and community composition (in terms of abundance) were considered significantly different if the calculated difference (F) obtained from the ANOVA was greater than the critical difference (F_{crit}; Appendix II-B3).

Overall Distribution and Composition

During the 1994 ice-free season, a total of 119 drifting invertebrate taxa were identified (Table 3.1-9). Of the 21 major groups found, dipterans (true flies) dominated. They were the only taxon present in every stream site during all sampling seasons, accounting for 74% of the individuals collected (Table 3.1-10). Cladocera (water fleas) and Arachnida (spiders and mites) were the next largest of the major taxonomic groups, with only five others contributing >1% to the community (i.e., Ostracoda, Branchiopoda, Ephemeroptera, Plecoptera and Trichoptera).

The dominant dipteran genus was *Simulium* (larval stage), comprising 18% of the total number of individuals over the entire ice-free sampling season (primarily due to a large sample of 3,894 individuals at Site 21 [Nancy-Long] in June). The dipteran *Prosimulium* (larvae) followed, representing 12% of the drift fauna. *Psectrocladius* was the most widespread genus, occurring at 27 of 37 sites. *Brachycentrus*, *Procladius* and *Rheotanytarsus* were also common. They were found at 18 sites.

Site 21 (Nancy-Long) yielded 8,119 invertebrates in June, this being the largest number of individuals at any one site in a sampling period. Site 18 (Leslie-Moose) yielded consistently large abundances of invertebrates and had the greatest number of taxa of all sites in each of the three sampling periods. Sites 13 (Airstrip-Larry) and 26 (Koala-Kodiak) had low numbers of drift organisms with a total of 168 (over three seasons) and 84 individuals (over two seasons), respectively. Using all sites and all three sampling periods, an average of 619 invertebrates per drift set was calculated.

Seasonal Distribution

In order to compare seasonal differences equitably, only the seven stream sites that were sampled in all three seasons were used in the analyses. Overall, the total abundance of drifting invertebrates obtained from these seven sites decreased from 4,186 individuals in June, to 3,685 in August and to 1,033 in September.

Table 3.1-9
Larval Drift Taxa Identified in 1994 Streams Samples

Major Taxonomic Group	Family, Genus or Species	June (15 sites)	August (12 sites)	September (10 sites)
COELENTERATA	*Hydra*	+	+	+
NEMATODA	Nematoda spp.	+	+	+
TURBELLARIA	Turbellaria spp.	+		
TARDIGRADA	Tardigrada spp.	+		
OLIGOCHAETA	*Limnedrilus*		+	
	Lumbriculidae	+		
	Naididae		+	+
	Nais		+	
	Pristina	+		
CLADOCERA	*Alonella*		+	
	Chydoridae		+	+
	Eurycercus		+	+
	Macrothricidae			+
	Ophyroxus		+	+
HARPACTICOIDA	Canthocamptidae		+	
OSTRACODA	*Candona*	+	+	+
	Cypria	+	+	+
	Cypris	+	+	
BRANCHIOPODA	Anocostraca	+		
	Notostraca	+		
ARACHNIDA	*Acarina* (parasitic)	+		
	Aranea	+		+
	Hydracarina	+	+	+
	Oribatidae	+		
COLLEMBOLA	Entomobryidae	+		
	Isotoma			+
	Isotomidae	+		
	Poduridae	+		
	Sminthurus	+		+
PLECOPTERA	*Capnia*	+		
	Nemoura	+	+	
	Yugus			+
EPHEMEROPTERA	*Baetis tricaudatus*		+	
	Ephemerella inermis			+
	Ephemerella aurivilli		+	+
	Leptophlebiidae			+
	Parameletus	+		
HEMIPTERA	Aphididae	+		+
	Coccoidea	+		
	Miridae	+		

Note: + indicates taxon was present in at least one sample during that period.

(continued)

Table 3.1-9 (continued)
Larval Drift Taxa Identified in 1994 Streams Samples

Major Taxonomic Group	Family, Genus or Species	June (15 sites)	August (12 sites)	September (10 sites)
	Neocorixa			+
	Psyllidae		+	
TRICHOPTERA	*Agraylea*		+	
	Agrypnia			+
	Amiocentrus	+		
	Brachycentrus	+	+	+
	Ceraclea		+	
	Grensia	+	+	+
	Hesperophylax			+
	Limnephilidae	+		
	Limnephilus	+		+
	Mystacides		+	
	Onocosmoecus	+		
LEPIDOPTERA	Lepidoptera spp.	+		
COLEOPTERA	*Agabus*	+		
	Brachyvatus	+	+	+
	Carabidae	+		
	Coccinellidae	+		
	Curculionidae	+		
	Hydroporus	+	+	+
	Rhantus	+		
	Staphylinidae	+		+
	Uvarus	+		
HYMENOPTERA	Braconidae	+		+
	Chalcoidea	+		+
	Encyrtidae	+		
	Ichneumonidae	+		
	Tenthredinidae	+		
DIPTERA	*Ablabesmyia*	+		
	Aedes hexodontus	+		
	Anopheles	+		
	Bezzia	+		
	Canaceidae	+		
	Chelifera	+		
	Chironomidae	+	+	+
	Chironominae	+		
	Clinocera	+		
	Corynoneura	+	+	+
	Cricotopus	+	+	+

(continued)

Table 3.1-9 (completed)
Larval Drift Taxa Identified in 1994 Streams Samples

Major Taxonomic Group	Family, Genus or Species	June (15 sites)	August (12 sites)	September (10 sites)
	Diamesinae	+		+
	Epoicladius		+	
	Eukiefferiella	+	+	+
	Heterotrissocladius		+	
	Lasiodiamesa	+	+	
	Micropsectra	+	+	+
	Muscidae	+		
	Neozavrelia		+	
	Orthocladiinae	+	+	+
	Orthocladius	+	+	
	Paramerina	+		+
	Paratanytarsus	+		
	Pentaneurini	+		
	Phaenopsectra	+	+	+
	Polypedilum	+		
	Potthastia	+		
	Prionocera	+		
	Procladius	+	+	+
	Prosimulium	+		
	Protanypus	+		
	Psectrocladius	+	+	+
	Pseudokiefferiella	+		+
	Ptychopteridae	+		
	Rheotanytarsus	+	+	+
	Scyomyzidae	+		
	Simulidae	+	+	+
	Simulium	+	+	+
	Stempellinella		+	
	Syrphidae	+		
	Tanypodinae	+	+	+
	Tanytarsini	+	+	+
	Tanytarsus	+	+	
	Thienemanniella	+		
	Tipula	+	+	
	Tipulidae			+
	Trichotanypus	+		
	Zalutshia	+		
GASTROPODA	*Valvata sincera*	+	+	+
	Pisidium			+
FISH	*Cottus cognatus*	+		

Note: + indicates taxon was present in at least one sample during that period.

Table 3.1-10
Abundance of Major Taxonomic Groups in Larval Drift as a Percentage of the Entire Community

Major Taxonomic Group	Abundance Over Three Sampling Periods	Percentage of Total
Arachnida	826	3.6
Branchiopoda	822	3.6
Cladocera	1,818	7.9
Coelenterata	100	0.4
Coleoptera	32	0.1
Collembola	50	0.2
Diptera	16,935	73.9
Ephemeroptera	262	1.1
Fish	8	0.0
Gastropoda	35	0.2
Harpacticoida	2	0.0
Hemiptera	95	0.4
Hymenoptera	34	0.2
Lepidoptera	5	0.0
Nematoda	130	0.6
Oligochaeta	77	0.3
Ostracoda	722	3.2
Plecoptera	295	1.3
Tardigrada	1	0.0
Trichoptera	667	2.9
Turbellaria	1	0.0
Total	**22,917**	**100.0**

The abundance of dipterans also decreased substantially from June to August and to a lesser extent from August to September (Figure 3.1-4). In terms of percent composition, dipterans dominated all three seasons (Figure 3.1-5).

Seven ANOVA tests were conducted to compare temporal differences in major taxa at each site among the three sampling periods. Invertebrate composition was not significantly different over the ice-free period. However, three of seven sites (Sites 30, 31 and 42) varied significantly in terms of abundance (Appendix II-B3).

The second series of ANOVA tests were conducted to determine spatial variances of abundance and composition in major taxa (a total of three tests) among sites sampled for each season. Significant differences were found in community composition among sites. However, abundance varied significantly among sites in all three seasons (Appendix II-B3).

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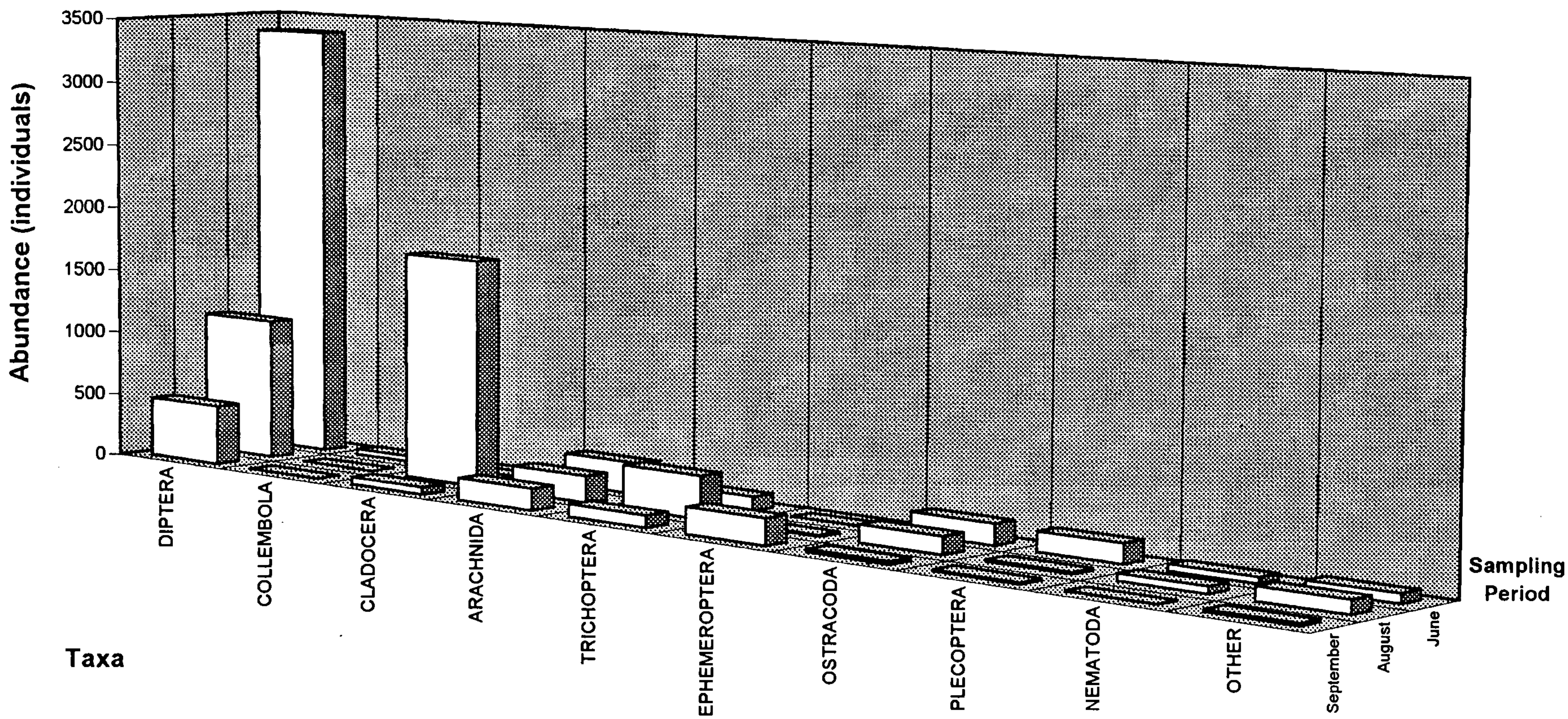
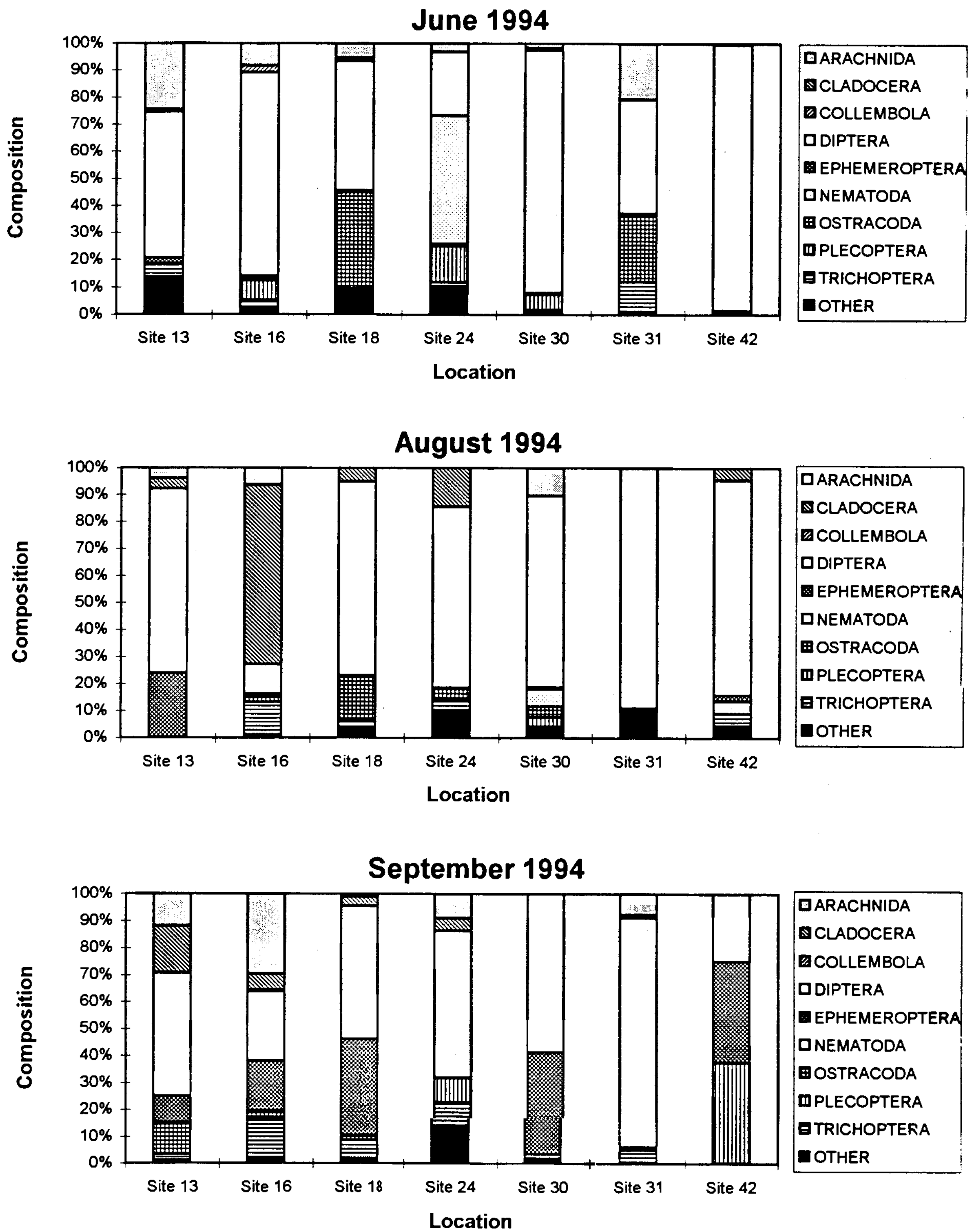
Cad No. a371s Job No. 455 03/29/1994-05:22pm Res_AV



NWT DIAMONDS PROJECT

Figure 3.1-4
Average Abundance of Larval Drift Taxonomic Groups

Source: Rescan



NWT DIAMONDS PROJECT

Figure 3.1-5
Percent Composition of Larval Drift Taxonomic Groups

Source: Rescan

These tests showed that there were both temporal and to a greater extent, spatial differences in the abundance, but not in the composition of larval drift samplings. In other words, the same organisms were found in each sampling period but in significantly different amounts.

Factors Affecting Variation

The mechanisms that regulate variation in stream drift are not well understood (Rosillon 1989). Factors that might affect larval drift rates include abiotic factors (current/discharge, water chemistry, temperature and photoperiod) as well as biotic factors (endogenous rhythms, life cycle stage, predators and competition) (Brittain and Eikeland 1988). Therefore, the complex nature of drift makes it difficult to explain in terms of one or even a few factors.

In the Koala and adjacent watersheds, eight out of the ten major taxa had lower abundances in the fall than in the spring or summer sampling periods. One possible explanation is that higher numbers earlier in the season reflect the regular annual variation in density of the benthos (Townsend 1980). Another is that a higher level of drift often occurs shortly before invertebrates pupate or emerge as adults. An increase in activity makes them more susceptible to being dislodged by the current (Townsend 1980). Finally, higher drift rates earlier in the sampling season may be related to stream flow rates. Faster water, related to increased springtime runoff, can disturb substrate habitats and send invertebrates upwards into the stream. A study of the streams flowing into Char Lake, NWT (de March *et al.* 1977), concluded that the drift was directly proportional to water velocity. More specifically, a later study found dipterans to be directly affected by volume of stream flow (Benke *et al.* 1991), which may explain the dramatic decrease in dipteran abundance over the ice-free season in the Koala study.

3.1.2.2 Stream Benthos

Flowing freshwater environments are referred to as lotic environments (Townsend 1980; Thorp and Covich 1991). The majority of invertebrate taxa found in lotic ecosystems are associated with stream beds and are referred to collectively as the benthos (Townsend 1980). The algae growing on the substrate are the stream's main primary producer; collectively, they are referred to as periphyton. Benthic invertebrates occupy a key position in aquatic communities, as grazers of algae and bacteria and as major prey items for fish and birds (Thorp and Covich 1991). Because of their sensitivity, stream invertebrates are also useful indicators of environmental change resulting from siltation or other causes.

Streams are usually a series of two essentially different but inter-related habitats (turbulent riffle and quiet pool). Riffles are characterized by greater habitat heterogeneity (diversity), higher gradients, coarser substrate and higher current velocities. They are generally shallower than pools (Thorp and Covich 1991). The overall production in a stream is influenced in part by the nature of the stream bed.

Above and below the riffles are the less productive pools, which offer less substrate for both periphyton and benthos. Gravel and rubble bottoms, which are typical of riffles, support the most abundant life because they have the greatest surface area for periphyton while providing many crevices and protected areas for invertebrates. Aquatic life is also richer in the riffles because lotic fauna depend on flowing water to aid their respiration and bring them food. Although stream riffles and pools provide quite different habitat conditions for aquatic invertebrates, these differences are reduced during high discharge (spring) when flows rates are increased throughout the stream.

Small invertebrate animals are attached to the rocks in the main flow or inhabit gravel interstices (spaces between rocks), the undersides of stones, or leaves packed into crevices. The interstitial spaces within the sediments of streams, called the hyporheic zone, offer shelter from predators, floods, drought and extreme temperatures. They also provide suitable and predictable conditions for immotile stages such as eggs, pupae and diapausing nymphs and larvae (Moss 1988; Ward 1992; Hynes *et al.* 1974). The hyporheic zone plays a major ecological role in streams with coarse substrates such as those found in the Koala region. The hyporheos form a faunal reservoir capable of partially recolonizing the surface benthos should the latter be depleted by adverse conditions (Palmer *et al.* 1991).

The hyporheic invertebrate fauna consists of permanent residents that do not normally occur as surface benthos (crustaceans, mites, nematodes and others); species that spend part of their aquatic lives in the hyporheic zone; and surface benthos (i.e., many stream insects; Ward 1992). For example, larvae of chironomids over winter at depth and migrate upward in spring when the surface water begins to warm up. Hyporheic insects must also move to the surface immediately prior to emergence (Ward 1992). Generally, aquatic insects are more numerous in the stream benthos than any other invertebrate class and typically extend 30 cm or more into the coarse substrate of streams (Ward 1992). Other groups that are less abundant include flatworms, oligochaete worms, molluscs, crustaceans and mites (Townsend 1980; Thorp and Covich 1991).

Benthic communities are influenced by physical, chemical and biological conditions (Thorp and Covich 1991). However, the balance of these factors may differ temporally and spatially in streams as in all ecosystems (Moss 1988).

Previous Research

Many studies have previously been conducted on stream and river benthos however, few studies focus on NWT subarctic stream benthos. The most relevant publications on northern stream benthos include studies by Hynes *et al.* (1974) who assessed arctic streams near Char Lake, and Rosenberg and Wiens (1978) studied the response of invertebrates to sediment addition in the Harris River, NWT (61°52'N 121°19'W). Irons (1988) studied benthic invertebrates in two Alaskan subarctic streams. De March (1976) studied benthic diversity in a river in

Manitoba (49°N 96°W). The studies mentioned are compared to the results of 1993 and 1994 studies conducted in the Koala and adjacent watersheds.

Methods

Benthic invertebrates were collected in spring (June 7 to 13), summer (August 2 to 10) and fall (September 11 to 20) of 1994. A total of 18 stream sites were assessed (Figures 2.4-1 to 2.4-4). Fourteen sites were sampled in June, 12 in August and 13 in September (Table 3.1-11). Three stream beds, Arnie, Mark and Misery, were not sampled due to subsurface flows.

Table 3.1-11
Summary of 1994 Stream Benthic Invertebrate Sampling

Site Number	Stream Location	Type[1]	Sampling Period Spring	Summer	Fall
6	Fox 1-Fox 2	I	+ [2]	S [3]	S
11	Larry-Nero	I	+	P [4]	+
13	Airstrip-Larry	P	+	+	+
16	Leslie-Moose	P	+	+	+
18	Long-Leslie	P	+	+	+
21	Nancy-Long	I	+	P	+
22	Little-Moose	I	B [5]	+	+
24	Kodiak-Little	P	+	+	+
26	Koala-Kodiak	P	+	+	+
28	Panda-Koala	I	+	+	S
30	Grizzly-Panda	P	+	+	+
31	Vulture-Polar	P	+	+	+
33	Slipper-Lac de Gras	P	+	+	+
36	Ursula (N)	P	+	+	+
42	South (W)	P	+	+	+
39	Arnie stream	I	S	S	S
49	Misery stream	I	S	S	S
47	Mark stream	I	S	S	S

1: I = Intermittent, P= Permanent.
2: + = Benthic samples collected.
3: S = Subsurface flow.
4: P = Pools only, no flow.
5: B = Boulders only (north end of stream).

Streams may experience very low seasonal flows and may periodically dry up. The environmental conditions of intermittent streams (lotic waters exhibiting surface flow for only a portion of each annual cycle) tend to be more variable, with distinctly different faunal composition and relatively higher abundances than permanent lotic habitats (Thorp and Covich 1991; Ward 1992). Due to the spatial and temporal variability of invertebrate communities in intermittent streams, overall seasonal comparisons were based on averages of ten streams sampled in all three sampling periods. Permanent stream sites included Airstrip-Larry, Leslie-Moose, Long-Leslie, Kodiak-Little, Koala-Kodiak, Grizzly-Panda, Vulture-Polar, Ursula (N), Lac de Gras-Slipper and South (W). Intermittent streams included Fox 1-Fox 2, Larry-Nero, Nancy-Long, Little-Moose, Panda-Koala, Arnie, Mark and Misery.

Field Sampling

A Hess sampler (area 0.096 m^2; 250 µm mesh size) was forced into the substrate in shallow riffle areas to a depth of approximately 10 cm. The substrate within the cylinder area was lifted and mixed to expose the whole sample area and allow the disturbed benthic invertebrates to be swept downstream into the catchment net. When stream flows were not sufficient to move materials from the cylinder into the net, water was physically directed through the cylinder into the net. Three replicates were collected at each site and preserved in 10% buffered formalin. A total of 102 samples were collected during the 1994 sampling program.

Benthic invertebrate analyses were performed by Applied Technical Services, Saanichton, B.C. Samples were rinsed with water through a three-sieve series (1,000 µm, 333 µm and 63 µm mesh size) to remove the preservative and obtain three size fractions. From each fraction, organisms were counted and stored by major taxonomic groups (e.g., chironomids, nematodes). If large numbers of a particular type of organism were present, the sample was sub-sampled by weight until a reasonable number of the group was counted (approximately 100). When all the samples had been sorted in the above manner, the organisms were identified where possible to the species level and then enumerated (Appendix II-B4).

Seasonal site characteristics of the ten permanent sites were determined using the COMM program (Appendix II-B4). These included density, richness (number of taxa per site), number of taxa contributing to 90% of the density, maximum dominance, diversity indices (Shannon and Simpson) and evenness indices (Pielou, Heip and Margalef). Species characteristics, including number of organisms, number of species, species rank, percentage dominance, presence, biological index, median, minimum and maximum, were also generated for each season (Appendix II-B4).

Transformations and Statistical Analyses

Two-way without replication analyses of variance tests (ANOVAs) were conducted on site and taxa data to determine significant differences in benthic community composition and standing crop. ANOVAs compared differences among sites and among seasons for the following variables: density of invertebrates, richness (number of taxa per site), community composition and substrate type (Table 3.1-12).

Separate and pooled variance T-tests were conducted to test the means of densities and richness for two substrate types (hard and soft) in permanent streams for each season (Table 3.1-13). T-tests were also conducted to test the mean site densities and diversity between the Koala watershed and the surrounding watersheds.

Overall Results and Discussion

Thirty invertebrate families consisting of 80 taxa were identified from stream sites in the Koala and adjacent watersheds sampled in 1994: two snails (Gastropoda), one bivalve mollusc (Bivalvia), five oligochaete worms (Oligochaeta), nine crustaceans (Cladocera and Ostracoda), three mites (Arachnida), two water bugs (Hemiptera), four water beetles (Coleoptera), three mayflies (Ephemeroptera), one stonefly (Plecoptera), ten caddisflies (Trichoptera) and 47 true flies (Diptera; Table 3.1-14). Coelenterata, Turbellaria, Nematoda and Tardigrada were also present but were not identified beyond phylum or class.

Community composition was not significantly different among the three seasons (Table 3.1-15). Koala-Kodiak had the fewest number of taxa of all sites sampled in each season, but overall site richness was not significantly different spatially or temporally. Aquatic insects accounted for most of the individuals collected, representing from 19% to 98% of the total invertebrate density at each site. The insect taxa included the immature stages of the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), Trichoptera (caddisflies), Coleoptera (beetles) and Diptera (true flies). Collembola (springtails) and Hemiptera (water bugs) were found in low numbers during the spring sampling program.

The biological index was used to determine the dominant invertebrates in each season. The spring sampling was dominated by unidentified nematode worms, chironomids (including *Corynoneura*, *Tanytarsus* and *Cricotopus*), a Crustacean (a Canthocamptidae copepod), unidentified turbellarian worms and an oligochaete worm (*Pristina*). The summer benthos was dominated by unidentified oligochaete and nematode worms, chironomids (*Psectrocladius* and *Procladius*), crustaceans (Chydoridae cladocerans, the ostracods *Candona* and *Cypria* and Canthocamptidae copepods). The fall stream benthos was dominated by unidentified oligochaetes and nematodes, chironomids (*Tanytarsus*, *Psectrocladius*, *Rheotanytarsus* and *Phaenopsectra*) and crustaceans (the ostracod *Candona* and Chydoridae cladocerans).

Table 3.1-12
Stream Hypotheses Tested Using ANOVAs on 1994 Benthic Invertebrate Data

	Null Hypothesis	Tested For	*df* [1]	*F* [2]	*Fcrit* [3]	*p*-value [4]	Result
	among seasons	mean taxa density of permanent sites	2	0.07	3.63	0.93	accept
No significant difference in community composition...	among permanent sites	spring	9	0.16	2.01	1.00	accept
		summer	9	0.12	2.03	1.00	accept
		fall	9	0.14	2.03	1.00	accept
	among seasons for all sites	seventeen benthic groups	2	0.3	3.29	0.74	accept
	among seasons	mean site density from permanent sites	2	0.38	3.55	0.69	accept
		mean taxa density from permanent sites	2	0.04	3.63	0.96	accept
No significant difference in density...	among permanent sites over three seasons	mean site densities	9	2.76	2.46	0.03	REJECT
	among permanent sites	spring	9	3.61	2.01	<0.05	REJECT
		summer	9	2.54	2.03	<0.05	REJECT
		fall	9	7.68	2.03	<0.05	REJECT
	among seasons	mean site richness from permanent sites	2	0.22	3.55	0.80	accept
No significant difference in richness...	among permanent sites	three seasons	9	2.95	2.46	<0.05	REJECT
	among all sites	three seasons	16	1.79	1.97	0.08	accept
	among three seasons for all sites	mean richness	2	0.15	3.29	0.86	accept

1: *df* = degrees of freedom.
2: *F* = calculated difference.
3: *Fcrit* = critical difference.
4: *p-value* = probability of non-significance.

Table 3.1-13
Stream Hypotheses Tested Using T-tests on 1994 Benthic Invertebrate Data

Null Hypothesis	Tested For	During	*df*[1]	*T*[2]	*Tcrit*[3]	*p*-value[4]	Result
No significant difference in density between hard and soft substrates...	average permanent site values in...	spring	8	1.27	2.31	0.24	accept
		summer	8	0.34	2.31	0.08	accept
		fall	8	2.63	2.31	0.03	REJECT
	entire sampling season		28	2.48	2.05	0.02	REJECT
No significant difference in density between Koala watershed and surrounding watersheds...	entire sampling season		37	-1.17	2.03	0.25	accept
No significant difference in richness between hard and soft substrates...	entire sampling season		12	2.92	2.18	0.01	REJECT
	average permanent site values in...	spring	3	0.74	3.18	0.51	accept
		summer	3	1.06	3.18	0.37	accept
		fall	6	4.74	2.45	0.00	REJECT
No significant difference in richness between Koala watershed and surrounding watersheds...	entire sampling season		37	-0.14	2.03	0.89	accept

1: *df* = degrees of freedom.
2: *T* = calculated difference.
3: *Tcrit* = critical difference.
4: *p-value* = probability of non-significance.

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Table 3.1-14
Stream Benthos Identified from Sites Sampled in 1994

Phylum	Class	Order	Family	Genus/Species	Spring	Summer	Fall
ANNELIDA	OLIGOCHAETA		Enchytraeidae	unidentified		+	+
	(roundworms)		Lumbriculidae	*Limnedrilus*		+	+
			Lumbriculidae	unidentified			
			Naididae	unidentified	+	+	+
			Naididae	*Nais*		+	+
			Naididae	*Pristina*	+		
			Tubificidae	unidentified		+	
ARTHROPODA	ARACHNIDA			*Acarina*	+		+
	(mites, spiders)			*Hydracarina*	+	+	+
			Oribatidae	unidentified	+		+
ARTHROPODA	INSECTA	COLEOPTERA	Dytiscidae	*Brachyvatus*	+		
	(insects)	(water beetles)	Dytiscidae	*Hydroporus*		+	
			Haliplidae	*Haliplus*	+	+	
			Smithuridae	*Sminthurus*	+		
		DIPTERA	Ceratopogonidae	*Aedes hexodontus*	+		
		(true flies)	Ceratopogonidae	*Bezzia*	+	+	+
			Ceratopogonidae	*Culicoides*	+		
			Chironomidae	*Chironomus*		+	
			Chironomidae	*Conchapelopia*	+		
			Chironomidae	*Corynoneura*	+	+	+
			Chironomidae	*Cricotopus*	+	+	+
			Chironomidae	*Demicryptochironomus*	+	+	+
			Chironomidae	*Dicrotendipes*	+	+	+
			Chironomidae	*Eukiefferiella*	+	+	+
			Chironomidae	*Euryhapsis*	+	+	+
			Chironomidae	*Gymnometriocnemus*			+
			Chironomidae	*Heterotanytarsus*		+	+
			Chironomidae	*Heterotrissocladius*			+
			Chironomidae	*Lasiodiamesa*	+		
			Chironomidae	Macropelopiini	+		
			Chironomidae	*Micropsectra*	+	+	+
			Chironomidae	*Microtendipes*			+
			Chironomidae	*Orthocladius*			+
			Chironomidae	*Pagastiella*			+
			Chironomidae	*Parachironomus*			+
			Chironomidae	*Paracladopelma*	+	+	
			Chironomidae	*Paramerina*	+	+	+
			Chironomidae	*Paraphaenocladius*			+

Note: + indicates presence during that sampling period.

(continued)

Table 3.1-14
Stream Benthos Identified from Sites Sampled in 1994

Phylum	Class	Order	Family	Genus/Species	Spring	Summer	Fall
ARTHROPODA	INSECTA	DIPTERA	Chironomidae	Pentaneurini	+		
		(true flies)	Chironomidae	*Phaenopsectra*	+	+	+
			Chironomidae	*Potthastia*		+	+
			Chironomidae	*Procladius*	+	+	+
			Chironomidae	*Prosimulium*	+		
			Chironomidae	*Psectrocladius*	+	+	+
			Chironomidae	*Pseudokiefferiella*	+	+	+
			Chironomidae	*Pseudosmittia*			+
			Chironomidae	*Rheotanytarsus*	+	+	+
			Chironomidae	*Stempellinella*	+	+	+
			Chironomidae	*Stictochironomus*			+
			Chironomidae	*Tanytarsus*	+	+	+
			Chironomidae	*Thienemanniella*	+	+	
			Chironomidae	*Xenochironomus*			+
			Chironomidae	*Zalutschia*	+	+	+
			Chironomidae	unidentified	+	+	+
			Empididae	*Chelifera*	+		+
			Empididae	*Clinocera*	+	+	
			Empididae	*Oreogoton*		+	+
			Muscidae	*Limnophora*		+	+
			Simulidae	*Simulium*	+		
			Simulidae	unidentified	+	+	+
			Tipulidae	*Dicranota*		+	
			Tipulidae	*Hexatoma*		+	+
			Tipulidae	*Tipula*	+	+	+
		EPHEMEROPTERA		*Baetis tricaudatus*		+	+
		(mayflies)		*Ephemerella inermis*		+	+
				Paraleptophlebia		+	
				unidentified	+		
		HEMIPTERA	Aphididae	unidentified	+		
		(water bugs)	Coccoidea	unidentified	+		
		PLECOPTERA	Nemouridae	*Nemoura*	+	+	+
		(stoneflies)	Nemouridae	unidentified	+		+
		TRICHOPTERA		*Onocosmoecus*	+		
		(caddisflies)	Brachycentridae	*Brachycentrus*	+	+	+
			Hydroptilidae	*Agraylea*	+	+	+
			Hydroptilidae	*Hydroptila*		+	

Note: + indicates presence during that sampling period.

(continued)

Table 3.1-14
Stream Benthos Identified from Sites Sampled in 1994

Phylum	Class	Order	Family	Genus/Species	Spring	Summer	Fall
ARTHROPODA	INSECTA	TRICHOPTERA	Hydroptilidae	*Oxyethira*	+	+	+
		(caddisflies)	Leptoceridae	unidentified	+		
			Limnephilidae	*Apatania*			+
			Limnephilidae	*Grensia*	+	+	+
			Limnephilidae	unidentified		+	
			Phryganeidae	*Agrypnia*			+
			Rhyacophilidae	*Rhyacophila*	+		+
COELENTERATA (hydroids)				*Hydra*	+	+	+
CRUSTACEA	CLADOCERA		Chydoridae	*Alona*			+
	(water fleas)		Chydoridae	*Alonella*		+	+
			Chydoridae	*Chydorus*			+
			Chydoridae	*Eurycercus*		+	
			Chydoridae	unidentified		+	+
			Macrothricidae	*Ophyroxus*		+	+
		NOTOSTRACA		unidentified	+		
CRUSTACEA	COPEPODA	HARPACTICOIDA	Canthocamptidae	unidentified	+	+	+
CRUSTACEA	OSTRACODA			*Candona*	+	+	+
				Cypria		+	+
MOLLUSCA	GASTROPODA		Valvatidae	*Valvata sincera*	+	+	+
	(snails)		Lymnaeidae	*Lymnaea*		+	+
MOLLUSCA	BIVALVIA (clams)		Sphaeriidae	*Pisidium*			+
NEMATODA (round worms)				unidentified	+	+	+
PLATYHELMINTHES	TURBELLARIA (flat worms)			unidentified	+	+	
TARDIGRADA (water bears)				unidentified	+		+

Note: + indicates presence during that sampling period.

Table 3.1-15
Site Parameters for Permanent Streams Sampled in Spring, Summer and Fall, 1994

Site No.	Site Name	Sum[1]	No. of Taxa (S)	S(90%)[2]	Maximum[3] Dominance	Diversity Indices: Shannon	Diversity Indices: Simpson	Evenness Indices: Pielou	Evenness Indices: Heip	Evenness Indices: Margalef
					SPRING					
13	Airstrip-Larry	15,554	24	4	70.1	1.219	0.493	0.383	0.104	2.383
16	Leslie-Moose	8,631	36	13	41.4	2.318	0.798	0.647	0.262	3.862
18	Long-Leslie	6,905	30	11	26.1	2.410	0.870	0.709	0.350	3.281
24	Kodiak-Little	9,761	29	6	48.8	1.771	0.712	0.526	0.174	3.048
26	Koala-Kodiak	499	15	7	34.0	1.964	0.803	0.725	0.438	2.253
30	Grizzly-Panda	4,305	28	9	49.0	1.889	0.716	0.567	0.208	3.227
31	Vulture-Polar	12,968	29	8	39.8	1.817	0.733	0.539	0.184	2.957
33	Lac de Gras-Slipper	4,492	22	6	50.4	1.610	0.681	0.521	0.191	2.497
36	Ursula (N)	5,716	29	8	46.6	2.023	0.752	0.601	0.234	3.237
42	South (W)	7,924	27	7	56.0	1.695	0.659	0.514	0.171	2.896
					SUMMER					
13	Airstrip-Larry	18,420	32	6	37.8	1.759	0.744	0.507	0.155	3.156
16	Leslie-Moose	4,132	22	9	43.6	1.986	0.764	0.643	0.299	2.522
18	Long-Leslie	5,130	27	9	16.4	2.409	0.885	0.731	0.389	3.043
24	Kodiak-Little	12,507	32	8	48.5	1.908	0.728	0.551	0.185	3.286
26	Koala-Kodiak	1,265	18	8	35.1	2.073	0.814	0.717	0.409	2.380
30	Grizzly-Panda	5,186	19	9	37.5	2.095	0.807	0.712	0.396	2.104
31	Vulture-Polar	3,283	30	8	30.1	2.127	0.822	0.625	0.255	3.582
33	Lac de Gras-Slipper	11,176	29	7	40.2	1.902	0.765	0.565	0.204	3.004
36	Ursula (N)	66,148	19	1	91.1	0.485	0.169	0.165	0.035	1.622
42	South (W)	11,106	27	6	36.8	1.825	0.762	0.554	0.200	2.791
					FALL					
13	Airstrip-Larry	13,557	24	8	33.8	2.153	0.826	0.678	0.331	2.417
16	Leslie-Moose	66,048	33	4	81.6	0.942	0.330	0.270	0.049	2.883
18	Long-Leslie	24,431	31	8	45.1	1.834	0.731	0.534	0.175	2.969
24	Kodiak-Little	1,966	34	14	33.0	2.420	0.838	0.686	0.310	4.352
26	Koala-Kodiak	537	14	7	29.0	1.948	0.811	0.738	0.463	2.068
30	Grizzly-Panda	2,496	21	9	28.2	2.199	0.838	0.722	0.401	2.557
31	Vulture-Polar	957	20	10	28.6	2.221	0.837	0.741	0.432	2.768
33	Lac de Gras-Slipper	7,720	32	7	54.6	1.731	0.668	0.499	0.150	3.463
36	Ursula (N)	3,529	18	4	72.6	1.139	0.460	0.394	0.125	2.081
42	South (W)	16,406	32	9	44.1	2.078	0.771	0.600	0.226	3.194

1: Sum = total number of individuals in that sample.
2: S (90%) = number of taxa contributing to 90% of the density.
3: Maximum Dominance = percentage of total sum accounted for by the single-most abundant species.

Sampling in spring demonstrated that benthic density was comprised mainly of insects and nematodes, except in Nancy-Long, where molluscs dominated (Figure 3.1-6). Nematodes and dipteran insects were noted at all of the 14 sites sampled in spring. The lowest average seasonal densities were found in the spring. Spring communities are composed of insects that emerge early, eggs of taxa that hatch and grow during spring and summer, and benthic fauna that begin renewed growth after the winter slow-down. All sites in spring had densities less than 16,000 individuals/m^2, except Nancy-Long, which had 26,022 individuals/m^2. Fox 1-Fox 2, Larry-Nero, Koala-Kodiak and Panda-Koala had low spring densities, ranging from 205 individuals/m^2 to 1,373 individuals/m^2.

Summer stream benthos were generally dominated by insects and had more crustaceans and oligochaetes than in the spring sampling period (Figure 3.1-7). Arachnids, coelenterates, molluscs and turbellarians comprised the remainder of the community. Dipterans, nematodes and oligochaetes were present at all of the 12 sites sampled. All sites had densities under 20,000 individuals/m^2, except for Little-Moose (31,686 individuals/m^2) and Ursula (N) (66,148 individuals/m^2). Little-Moose and Ursula (N) were dominated solely by insects with 87% and 92%, respectively. Koala-Kodiak showed the lowest invertebrate density with 1,265 individuals/m^2.

Insects dominated the stream benthos in the fall for all sites except Airstrip-Larry and Long-Leslie which were also well represented by nematodes (Figure 3.1-8). Benthic communities also included arachnids, coelenterates, molluscs, oligochaetes and tardigrads. All 13 sites sampled were represented by ostracods (crustacean) and dipterans (insect). Densities were below 25,000 individuals/m^2, except for Leslie-Moose and Little-Moose with 66,047 individuals/m^2 and 43,461 individuals/m^2, respectively. Koala-Kodiak and Vulture-Polar exhibited the lowest total invertebrate densities (Figure 3.1-8).

Fluctuating currents or flows are the most obvious sources of disturbance in lotic systems (Thorp and Covich 1991). As no significant differences in richness or density were found between the Koala watershed streams (n = 33) and streams from surrounding watersheds (n = 6), variations in the composition and density of benthic communities were related more to differences in stream currents and substrates than to the site's location within the study area.

Seasonal Results and Discussion

During spring sampling, six major taxonomic groups (nematodes, insects, crustaceans, arachnids, turbellarians and oligochaetes) each accounted for more than 1% of the total community population. Thus, spring was the most diversified sampling period of 1994, as groups contributing more than 1% to the average seasonal abundance decreased from six to five to four as the ice-free period progressed (Figure 3.1-9). The diversity found in the spring is a reflection of the

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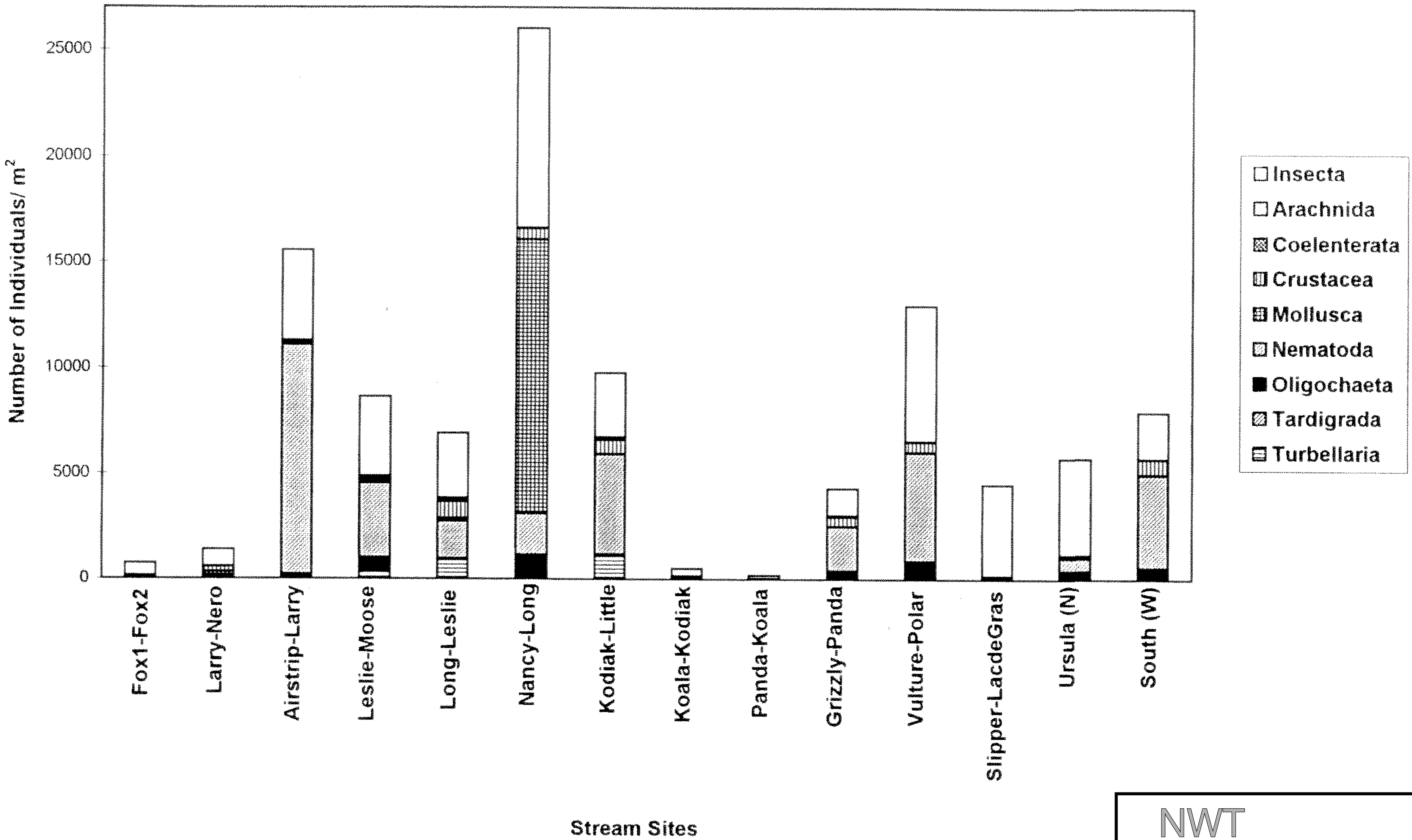

NWT DIAMONDS PROJECT

Figure 3.1-6
Density and Composition of Stream Benthos - Spring 1994

Source: Rescan

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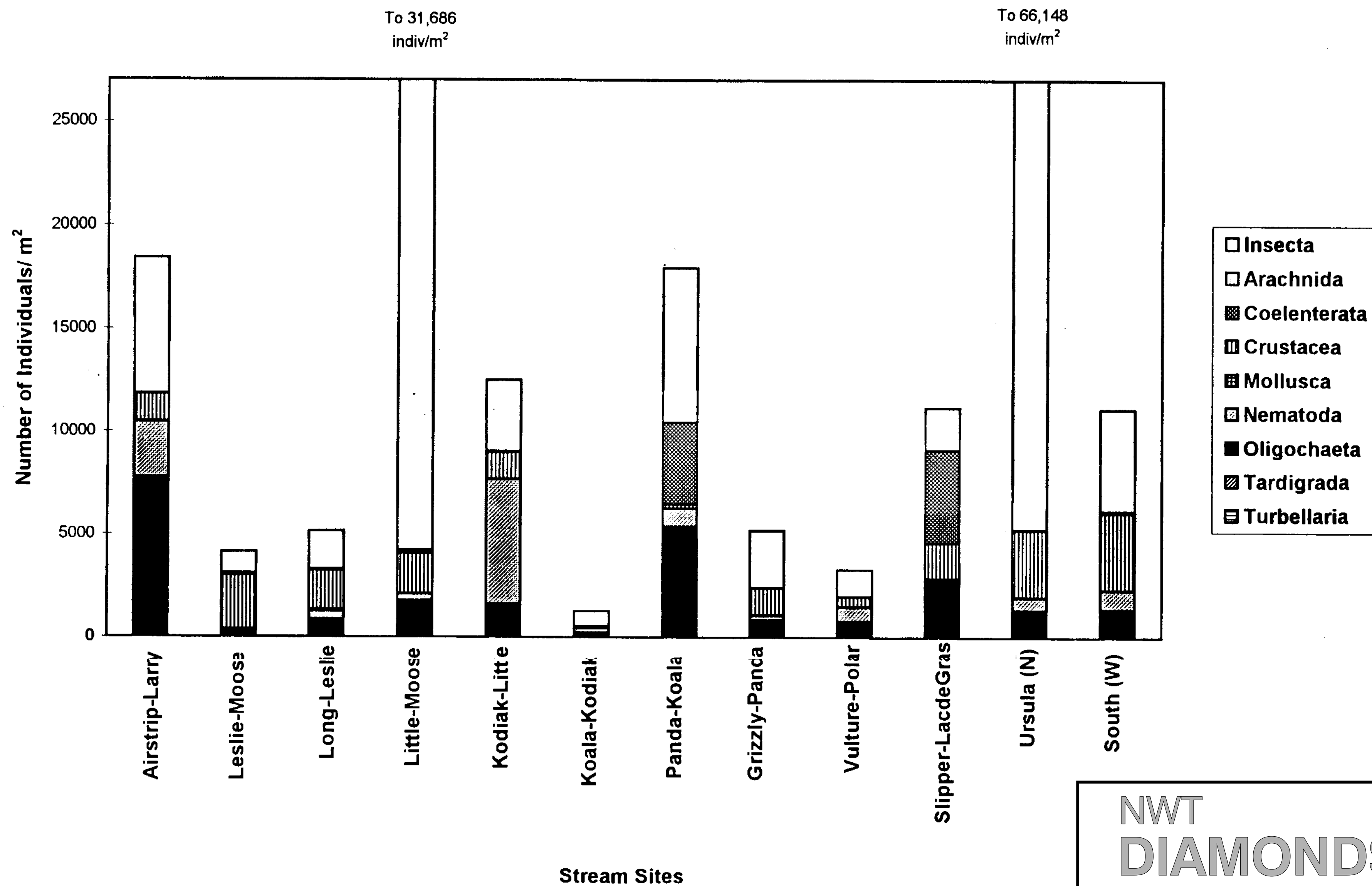

NWT DIAMONDS PROJECT

Figure 3.1-7
Density and Composition of Stream Benthos- Summer 1994

Source: Rescan

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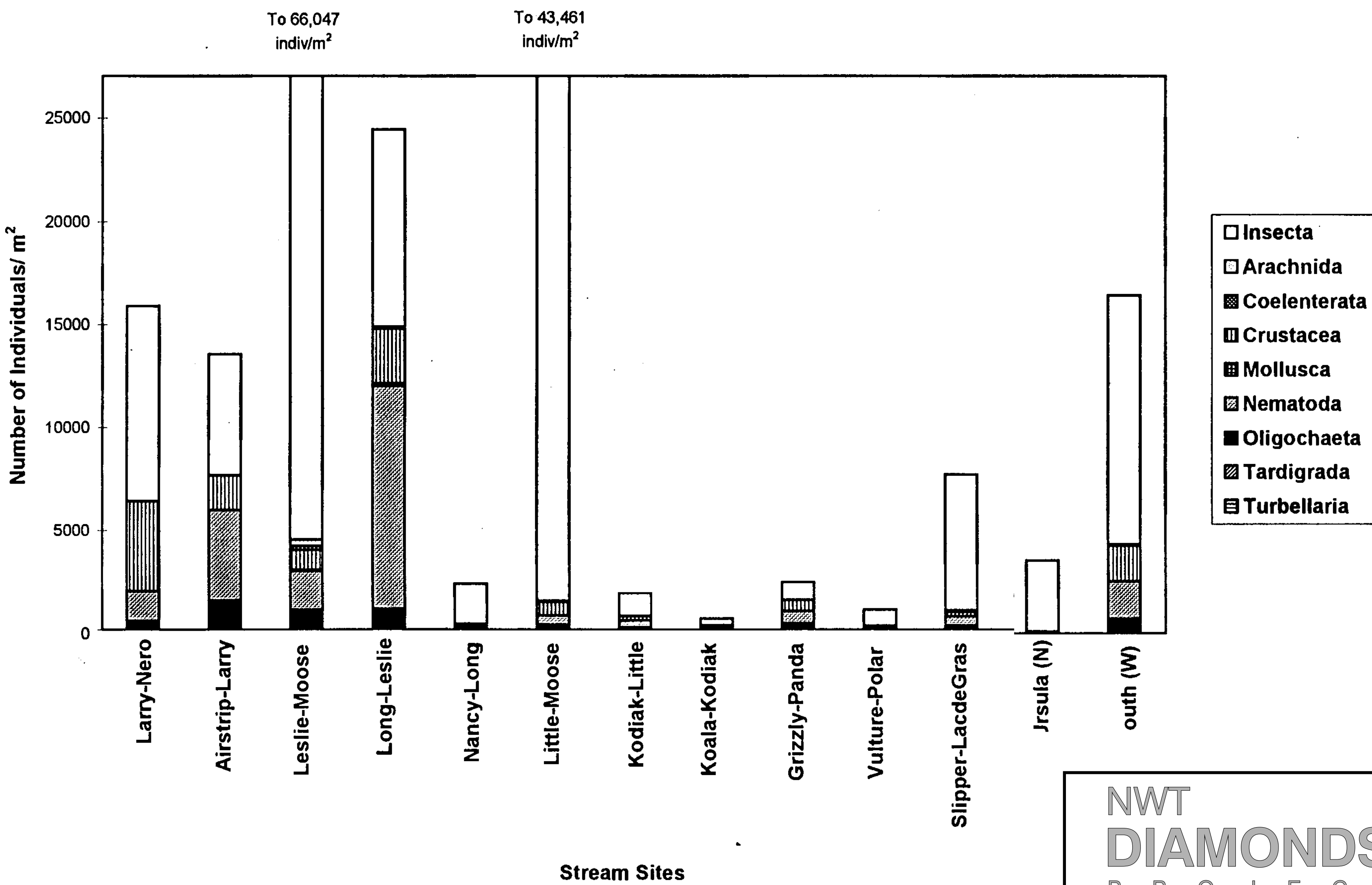
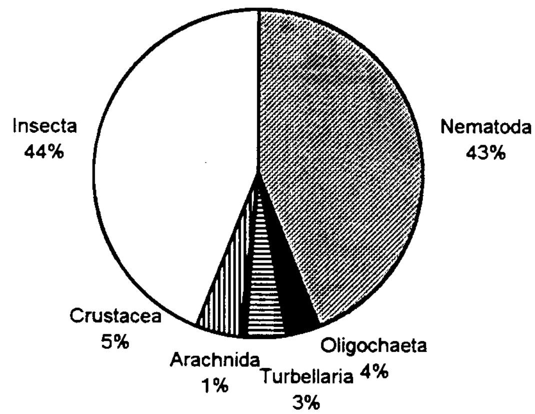


NWT DIAMONDS PROJECT

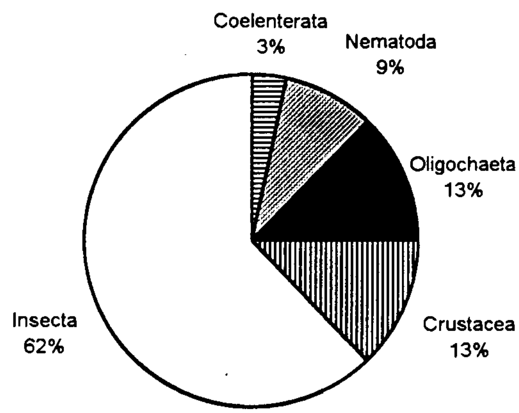
Figure 3.1-8
Density and Composition of Stream Benthos - Fall 1994

Source: Rescan

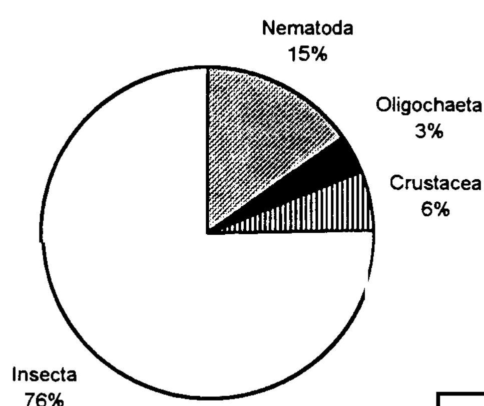
Spring 1994



Summer 1994



Fall 1994



NWT DIAMONDS PROJECT

Figure 3.1-9
Seasonal Stream Benthic Community Composition

Source: Rescan

lower metabolism of overwintering populations, and thus a reduction in competition for resources. Site richness did vary significantly ($p<0.05$) over seasons for the permanent sites due to low seasonal abundances in the Koala-Kodiak stream, which skewed the distributions (Figures 3.1-6 to 3.1-8).

The average benthic compositions for spring, summer and fall are presented in Figure 3.1-9. The summer sampling showed an increase in the contribution of coelenterates, crustaceans and oligochaetes, although insects continued to increase and dominate the communities. The fall sampling showed reduced percentages of oligochaetes and crustaceans, while nematodes and insects increased in abundance relative to summer and spring. There was an increase in the relative abundance of insects from 44% in spring to 62% in summer and 76% in fall. Dipterans were the dominant insect order, accounting for at least 95% of insects during the three sampling periods. Chironomidae was the dominant dipteran family. This compares with other arctic stream studies in which chironomid larvae comprised 70% to 80% of the benthic density (Hynes *et al.* 1974).

Overall, community composition among the permanent streams was not significantly different in spring, summer or fall, or over the entire sampling season (Appendix II-B4). Average seasonal site densities (based on permanent sites) and average seasonal benthic densities (based on 17 taxonomic groups) were not significantly different, indicating that temporal variation is not a determining factor in overall benthic productivity. Significant differences ($p<0.05$) in density were observed among the permanent sites over the 1994 sampling season as well as within each of the three sampling periods, indicating high spatial variation.

Heterogeneity

Lotic waters provide a dynamic mosaic of habitat types for benthic fauna partly because of variations in flow rates. In addition to directly affecting stream morphology, current and discharge interact with other ecological variables (e.g., substrate, food supply, dissolved oxygen) to determine habitat conditions for aquatic insects. The complexity of the interactions often confounds attempts to assess the relative importance of the variables involved, especially under field conditions.

Substrate

Substrate is one of the primary factors controlling the distribution and abundance of aquatic invertebrates (Simpson *et al.* 1982; Reice *et al.* 1990). The physical nature of the substrate can influence invertebrate distribution in a number of ways. For example, invertebrates that need a firm base for a sedentary way of life, such as *Simulium* spp. and net-spinning caddis larvae, are not found where the substrate is unstable or fine-grained.

Few aquatic insects are restricted to a specific substrate, but many benthic species exhibit distinct preferences for one or another general bottom type. Pools consisting mainly of fine (soft) substrates support populations comprised of chironomids, oligochaetes and burrowing mayflies (Simpson *et al*. 1982). The greatest density and diversity of groups, such as stoneflies and caddisflies, among other benthic larvae, are usually found on rocky (hard) substrates in riffle areas (Simpson *et al.* 1982).

To determine the relationship between the stream community structure and substrate, the invertebrate community was compared for two substrate types for numeric and taxonomic consistency during each season. For the entire 1994 sampling period, permanent sites were divided into hard (n=21) and soft (n=9) substrate types. Sites with hard substrates included Airstrip-Larry, Leslie-Moose, Long-Leslie, Kodiak-Little, Grizzly-Panda and South (W). Soft substrate sites included Koala-Kodiak, Vulture-Polar and Ursula (N). In all three seasons, the soft substrates had a higher relative abundance of insects than the hard substrates (Figure 3.1-10).

The T-tests showed that hard substrates had significantly higher invertebrate densities and richness than soft substrates (Appendix II-B4). The relatively large number of insect taxa reported for hard substrates is a result of the stability and microhabitat diversity of this substrate type. The average number of taxa per site (site richness) was significantly less in soft substrates than in hard substrates for the entire ice-free season. On a seasonal basis, the fall period had significantly higher densities and richness with coarser substrates as flows decreased and habitats became more heterogeneous.

3.1.2.3 Zooplankton

Zooplankton are the minute aquatic and terrestrial organisms that constitute the animal portion of plankton in lakes. Drifting suspended in the water column, they are found most abundantly in pelagic lake habitat, i.e., in open water. Although they are primarily influenced by water currents, most species are capable of independent movement to some degree. The major taxonomic groups of zooplankton in freshwater lakes are Rotifera and Crustacea (Moss 1988). Crustaceans include cladocerans (water fleas) and copepods, which can be further subdivided into the calanoids and the cyclopoids.

Zooplankton are important in lake ecosystems as they are the link between primary producers (phytoplankton) and carnivores (invertebrates and fish). Fluctuations in zooplankton density are linked to changes in algal populations and act as indicators of the amount of available fish food.

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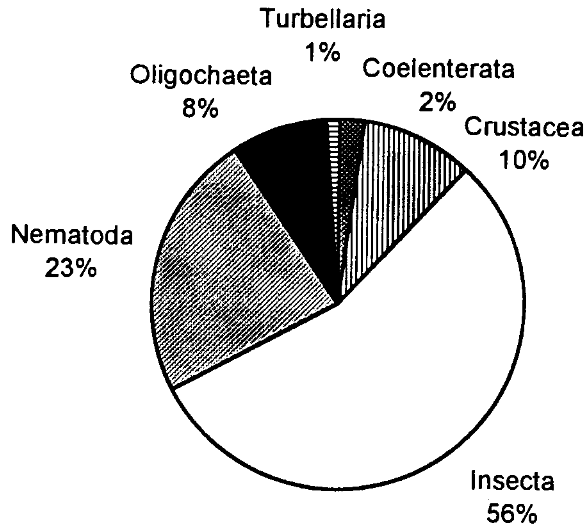
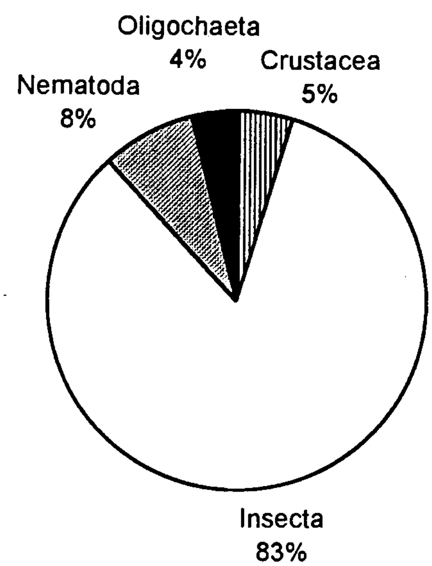
Hard Substrates



Soft Substrates



NWT DIAMONDS PROJECT

Figure 3.1-10
Stream Benthos Composition in Hard and Soft Substrates

Source: Rescan

Previous Research

Previous research conducted on zooplankton includes studies of lakes and rivers in Alaska by Kling *et al.* (1992), 19 subarctic lakes in the Yukon Territory by Shortreed and Stockner (1986), arctic tundra ponds by Herbert and Hann (1986), and Great Bear Lake by Johnson (1975). Most notable is a study of 18 arctic and subarctic lakes by Moore (1978a), where 17 of the lakes lie in the Southern Arctic Ecozone.

Methods

Zooplankton sampling was conducted over two periods during 1994 from June 28 to August 5 (early summer) and from August 12 to September 8 (late summer). Twenty-eight sites in 25 lakes (Figures 2.4-1 to 2.4-4) were sampled using Bongo and vertical haul nets of mesh sizes 330 µm and 164 µm, respectively. The vertical haul net was lowered into the water at the deepest part of the lake to sample the entire water column for zooplankton. The Bongo net was pulled horizontally across the width and length of the lake at a constant speed in order to maintain a uniform sampling depth of approximately 3 m.

Nets were rinsed with lake water and samples were transferred from the net cod-ends to 500 mL jars and preserved in formalin to ensure a final concentration of 10%. Identification and enumeration of zooplankton samples were conducted by Applied Technical Services, Saanichton, B.C. Samples were washed in a 64 µm Nitex sieve to remove excess preservative and transferred to a precalibrated 150 mL beaker. Each sample was filled to 100 mL and subsampled with a one or 10 mL Hensen Stempel pipette, depending on sample density. Subsamples were taken until at least ten individuals of a particular species were obtained; approximately 200 organisms were counted in total. The remainder of the sample was then re-examined for larger organisms found in low numbers (<5) in the subsamples.

Zooplankton were sorted using a Wild M5A dissecting microscope at 6X and 12X magnification. Species were identified using wet slide preparations with a Wild M12 compound microscope up to 40X magnification.

Statistical Analyses

Due to the known diurnal patterns of zooplankton (Grahame 1987), the data obtained from vertical tows were used to calculate the overall and seasonal results, as they provide zooplankton population information for the entire water column. Horizontal tows, on the other hand, sample only a portion of the water column; therefore, are more valuable in assessing species presence than making comparisons between seasons and among sites.

Two-way without replication analyses of variance (ANOVAs) were used at the 95% confidence level to determine significant differences in density, community composition and richness among the 28 sites and between sampling periods (Appendix II-B5).

Overall Distribution and Composition (in 1994)

Zooplankton identification and enumeration results for samples collected in 1994 are presented in Appendix II-B5. The predominant zooplankton identified from vertical and horizontal tows consisted of crustaceans and rotifers, although eubranchiopoda, decapoda and fish were represented by at least one species (Tables 3.1-16 and 3.1-17). Crustacea was the predominant phylum, making up 93% of the total number of individuals (Figure 3.1-11). The Rotifera were considerably less abundant, representing only 7% of the animal plankton. Copepods accounted for 81% of the crustaceans, while cladoceran crustaceans accounted for 12%. The two dominant copepod orders were equally represented, with Calanoida comprising 41% and Cyclopoida contributing 40% of the total zooplankton density.

Nineteen species (two rotifers, seven cladocerans and ten copepods) were identified from the two sampling periods in 1994 (Table 3.1-16). The three dominant species according to the biological index (McCloskey 1970) were *Kellicottia longispina* (rotifer), *Holopedium gibberum* (cladoceran) and *Diaptomus pribilofensis* (copepod). The species most frequently present was *Holopedium gibberum* found at 96% of the sites in both sampling seasons. *Kellicottia longispina* was present at 82% of the sites in the spring and 86% in the fall, while *Heterocope septentrionalis* was present at 89% of the sites during both seasons.

On a site-by-site basis, zooplankton density was greatest over the two sampling periods at Long Lake (Site 20), with Paul Lake (Site 53) and Fox 3 Lake (Site 5) containing slightly lesser numbers (Figure 3.1-12). These three sites had a total density of 521,922 individuals/m^3. Koala Lake (Site 27) zooplankton densities were lower than any other lake, with a total of only 11,713 individuals/m^3. Lac de Gras (Site 1) and Martine Lake (Site 4) also had low zooplankton levels, with densities of 34,839 individuals/m^3 and 22,892 individuals/m^3, respectively. Differences in zooplankton density between the 28 sites were significant in the early summer sampling, but not in the late summer (Appendix II-B5). Comparisons in community composition showed no significant differences among the 28 sites in either sampling period (Appendix II-B5). The number of species per lake (richness) ranged from seven to 15, with an average of 11 over both sampling periods.

According to T-test analyses, there were no significant differences in the zooplankton density between watersheds in the early summer, however, there

Table 3.1-16
Zooplankton Presence from Vertical Tows in 1993 and 1994

PHYLA **CLASS** **Order** *Species*	**August 1993** (10 Sites Sampled)	**June-August 1994** (28 Sites Sampled)	**August-September 1994** (28 Sites Sampled)
ROTIFERA			
Kellicottia longispina	+	+	+
Polyarthra vulgaris	+		
Keratella cochlearis	+		
Keratella quadrata	+		
Conochilus unicornis	+	+	+
EUBRANCHIOPODA			
Notostraca		+	
CRUSTACEA			
CLADOCERA			
Holopedium gibberum	+	+	+
Daphnia middendorffiana	+	+	+
Daphnia galatea mendotae	+	+	+
Daphnia longiremis		+	+
Bosmina longirostris	+	+	+
Camptocercus marcrurus	+		
Chydorus sphaericum		+	
Polyphemus pediculus		+	
COPEPODA			
Calanoida			
Diaptomus pribilofensis	+	+	+
Diaptomus sicilis	+	+	+
Diaptomus ashlandi		+	+
Heterocope septentrionalis	+	+	+
Epischura nevadensis		+	+
Cyclopoida			
Cyclops scutifer	+	+	+
Cyclops vernalis		+	
Cyclops b. thomasi	+	+	+
Cyclops capillatus		+	
Eucyclops agilis			+
Harpacticoida			
Canthocamptus spp.		+	

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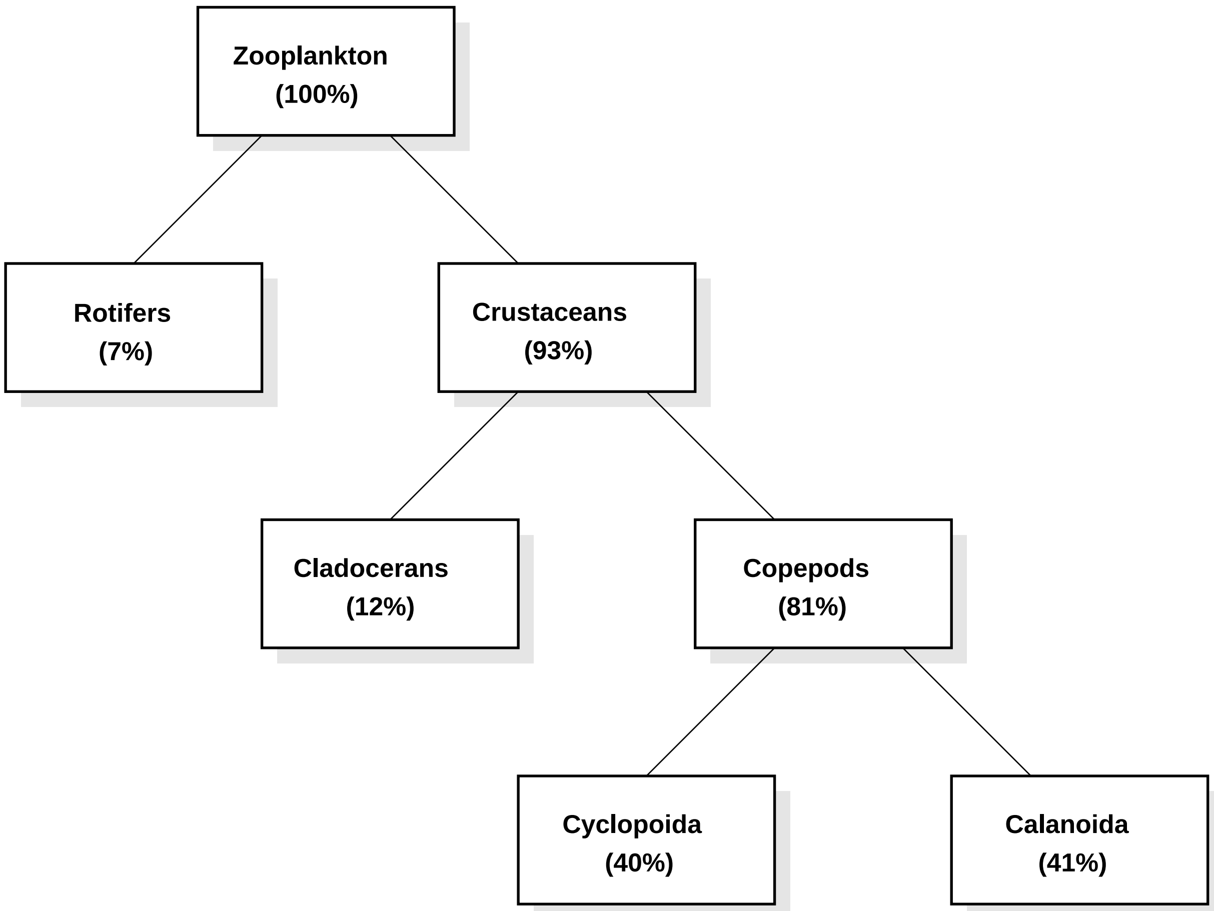
Table 3.1-17
Zooplankton Presence from Horizontal Tows in 1993 and 1994

PHYLA CLASS Order *Species*	August 1993 (10 Sites Sampled)	June-August 1994 (28 Sites Sampled)	August-September 1994 (28 Sites Sampled)
ROTIFERA			
Kellicottia longispina	+	+	+
Polyarthra vulgaris	+		
Keratella cochlearis	+		
Keratella quadrata	+		
Conochilus unicornis	+	+	+
CRUSTACEA			
CLADOCERA			
Holopedium gibberum	+	+	+
Daphnia middendorffiana	+	+	+
Daphnia galatea mendotae	+	+	+
Daphnia longiremis		+	+
Bosmina longirostris	+	+	+
Camptocercus marcrurus	+		
Chydoridae			+
Chydorus sphaericum			+
Eurycercus spp.		+	
Polyphemus pediculus		+	
COPEPODA			
Calanoida			
Diaptomus pribilofensis	+	+	+
Diaptomus sicilis	+	+	+
Diaptomus ashlandi		+	+
Heterocope septentrionalis	+	+	+
Epischura nevadensis		+	+
Cyclopoida			
Cyclops scutifer	+	+	+
Cyclops b. thomasi	+	+	+
Cyclops capillatus		+	+
DECAPODA		+	
FISH		+	



NWT DIAMONDS PROJECT

Figure 3.1-11
Breakdown of Major Taxonomic Groups

Source: Rescan

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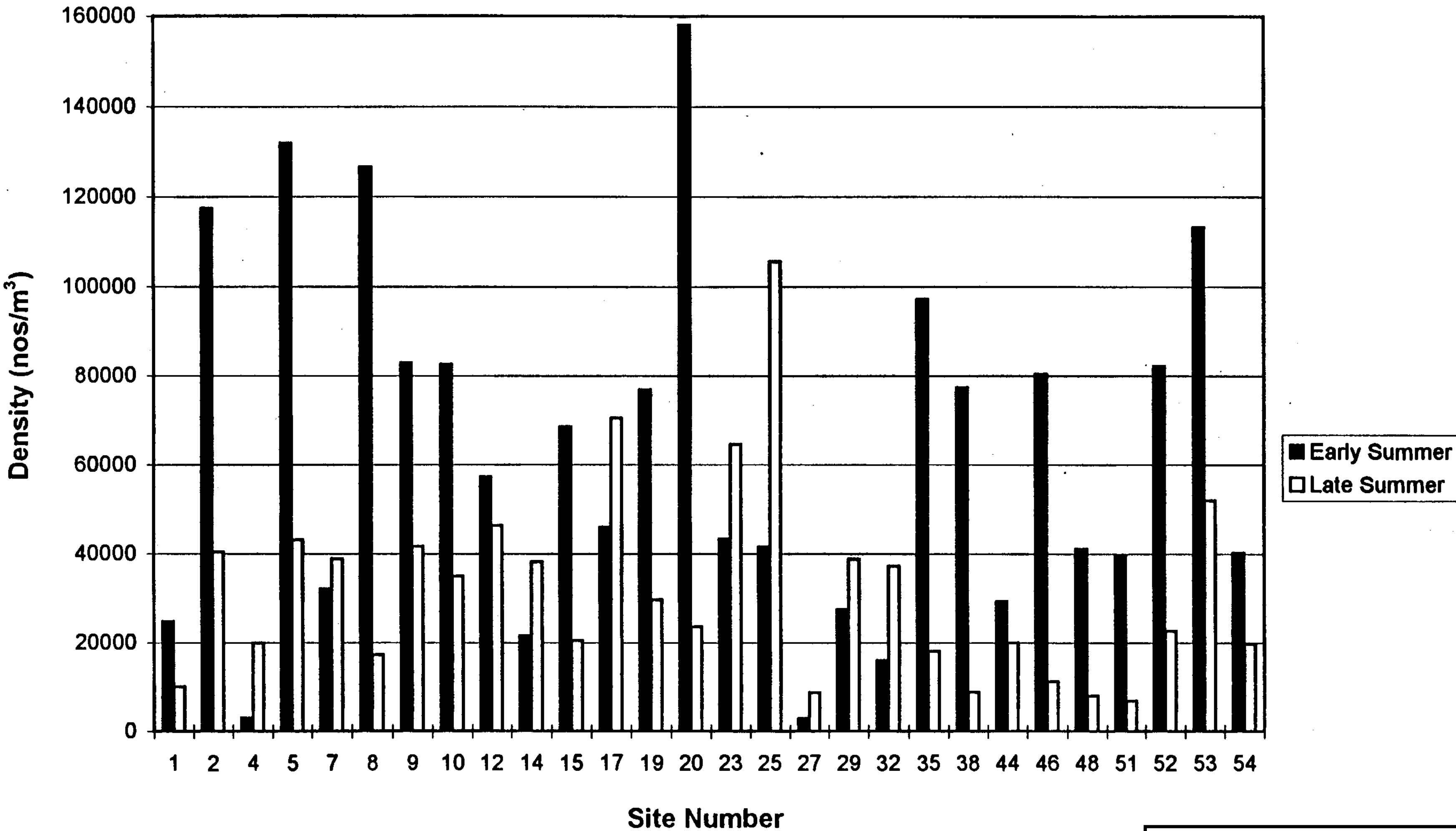

NWT DIAMONDS PROJECT

Figure 3.1-12
Seasonal Zooplankton Density at Each Site in 1994

Source: Rescan

were differences found in the late summer sampling period (Appendix II-B5). In terms of richness, there were significant differences between watersheds in the early summer, but not in the late summer.

Seasonal Distribution and Composition

Due to fluctuations in chemical and biological factors in the lake, zooplankton populations commonly exhibit irregular seasonal patterns (Moss 1980). Decreasing abundance was observed in all four major taxonomic groups of zooplankters from early to late summer (Figure 3.1-13), with 19 of the 28 sites supporting greater numbers of zooplankton in the early summer. Differences in zooplankton density for each site between the two sampling seasons were found to be significant.

The community composition (ratios of major taxonomic groups) of seven lakes was compared seasonally (Figure 3.1-14). The comparison showed that the zooplankton community composition differs seasonally, as seen in Fox 3 Lake, Koala Lake and Long Lake (north). Conversely, for some sites the composition of taxa remained constant over the two sampling periods, as observed in Fox 1 and Kodiak lakes.

While the physico-chemical nature of the water is important to zooplankton, previous studies have shown that phytoplankton density is usually the predominant factor affecting zooplankton density (Vanni 1987).

Within the time taken to sample all 28 sites twice, the lakes passed through three distinct phases of temperature stratification. Early in the ice-free season, heating of the surface waters causes the lakes to overturn, mixing nutrients, oxygen and plankton in the lake, resulting in uniform temperatures of about 4°C throughout the water column. As the summer progresses, the surface waters are heated causing them to be less dense. This differential heating or stratification imposes a degree of stability on the water column. As temperatures drop in the fall, the surface waters cool until the temperature again becomes homogeneous, allowing the whole lake to circulate.

Five of the first six lakes studied from June 28 to July 4 were not yet stratified; they had an average density of 30,008 individuals/m^3 (Figure 3.1-15). Of the 30 sites sampled from July 6 to August 18, 21 were stratified with an average density of 61,424 individuals/m^3. Thirteen of the final 20 sites sampled from August 20 to September 8 were post-stratified, with an average density of 36,973 individuals/m^3. The remaining lakes were either extremely shallow or extremely deep and therefore did not exhibit these patterns of stratification.

Seventy-nine percent of the cladocerans recorded in both sampling periods were present in the early summer, whereas 21% occurred in the late summer (Figure 3.1-16). This was the most noticeable decrease in density of the four

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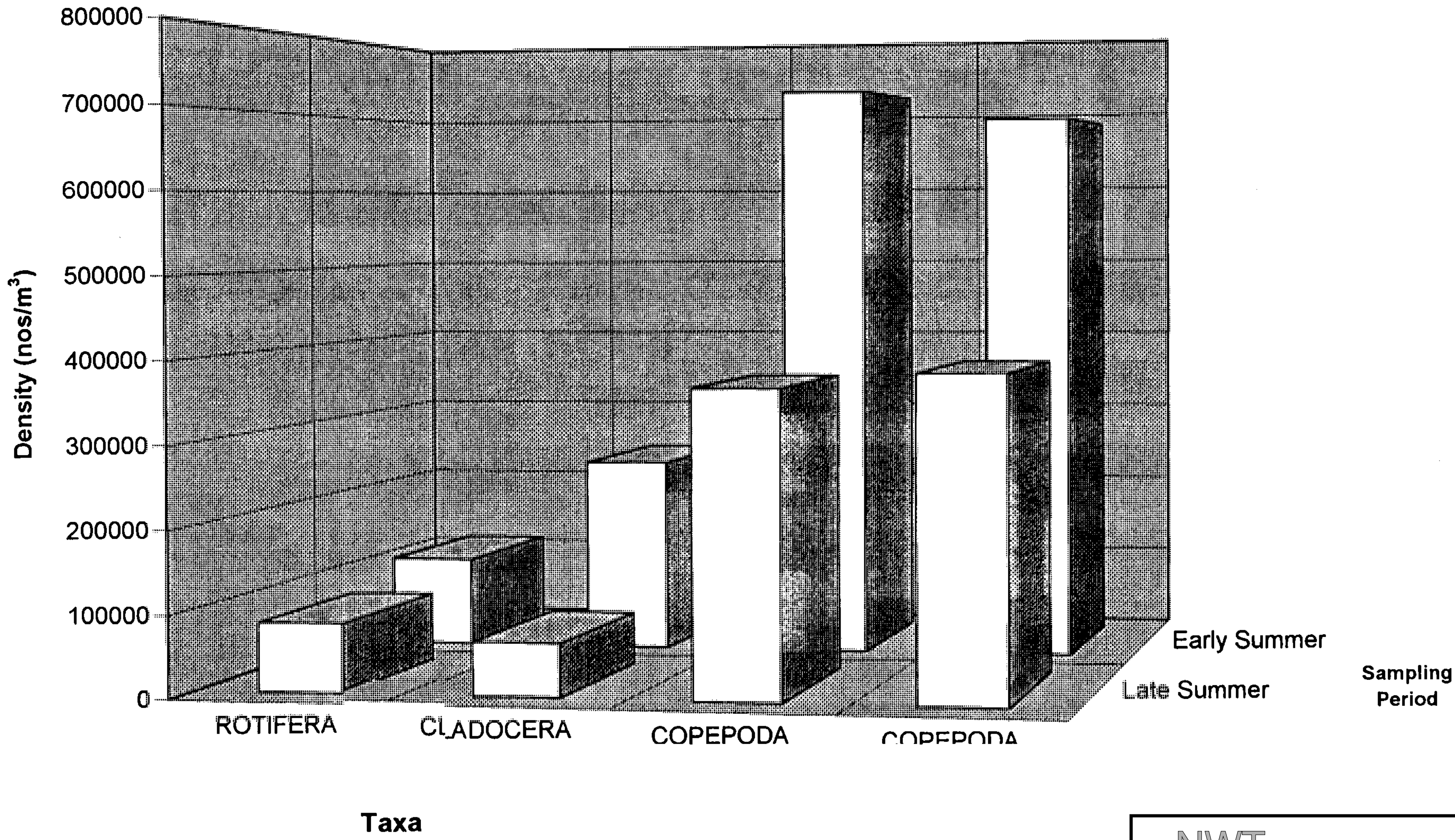
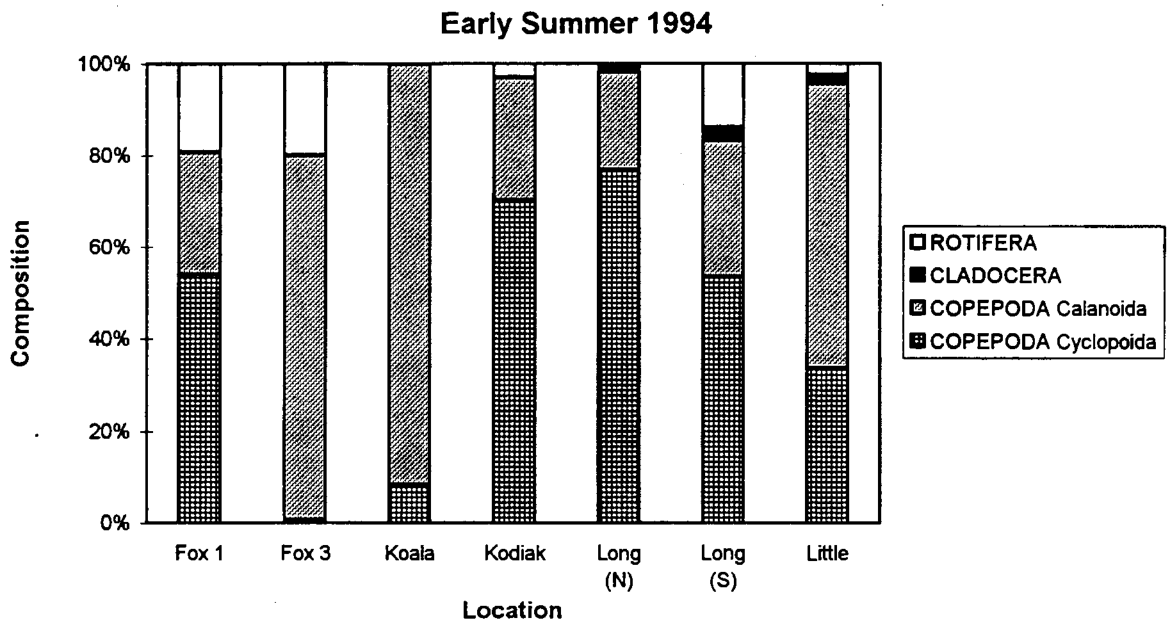
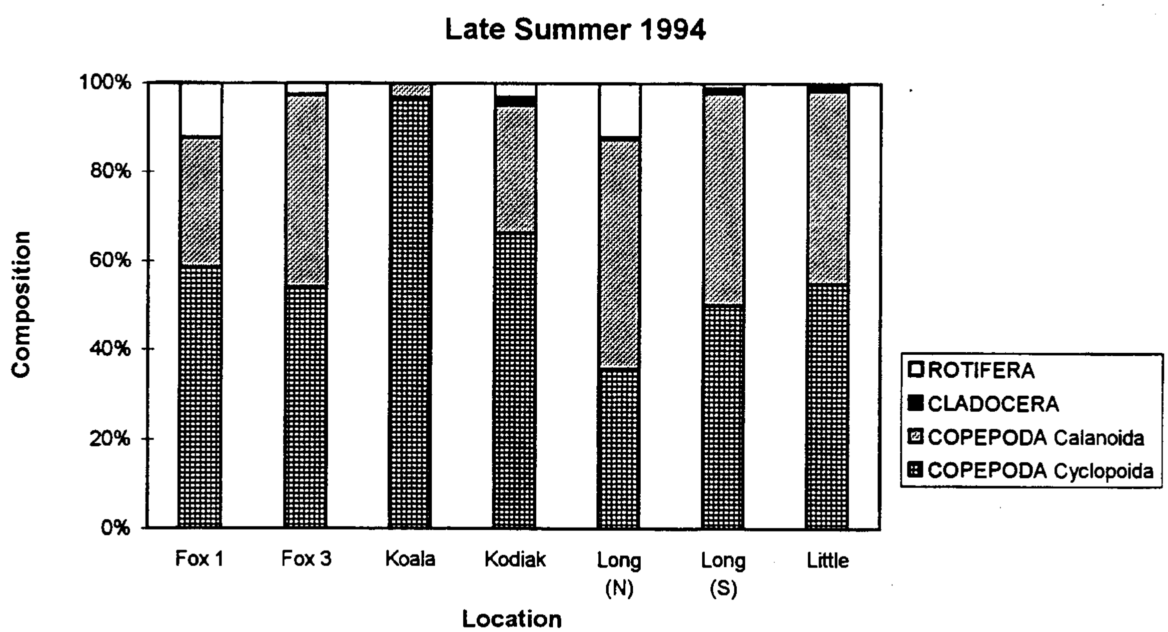


NWT DIAMONDS PROJECT

Figure 3.1-13
Average Density of Zooplankton Taxonomic Groups in 1994

Source: Rescan





NWT DIAMONDS PROJECT

Figure 3.1-14
Percent Composition of Zooplankton Taxonomic Groups

Source: Rescan

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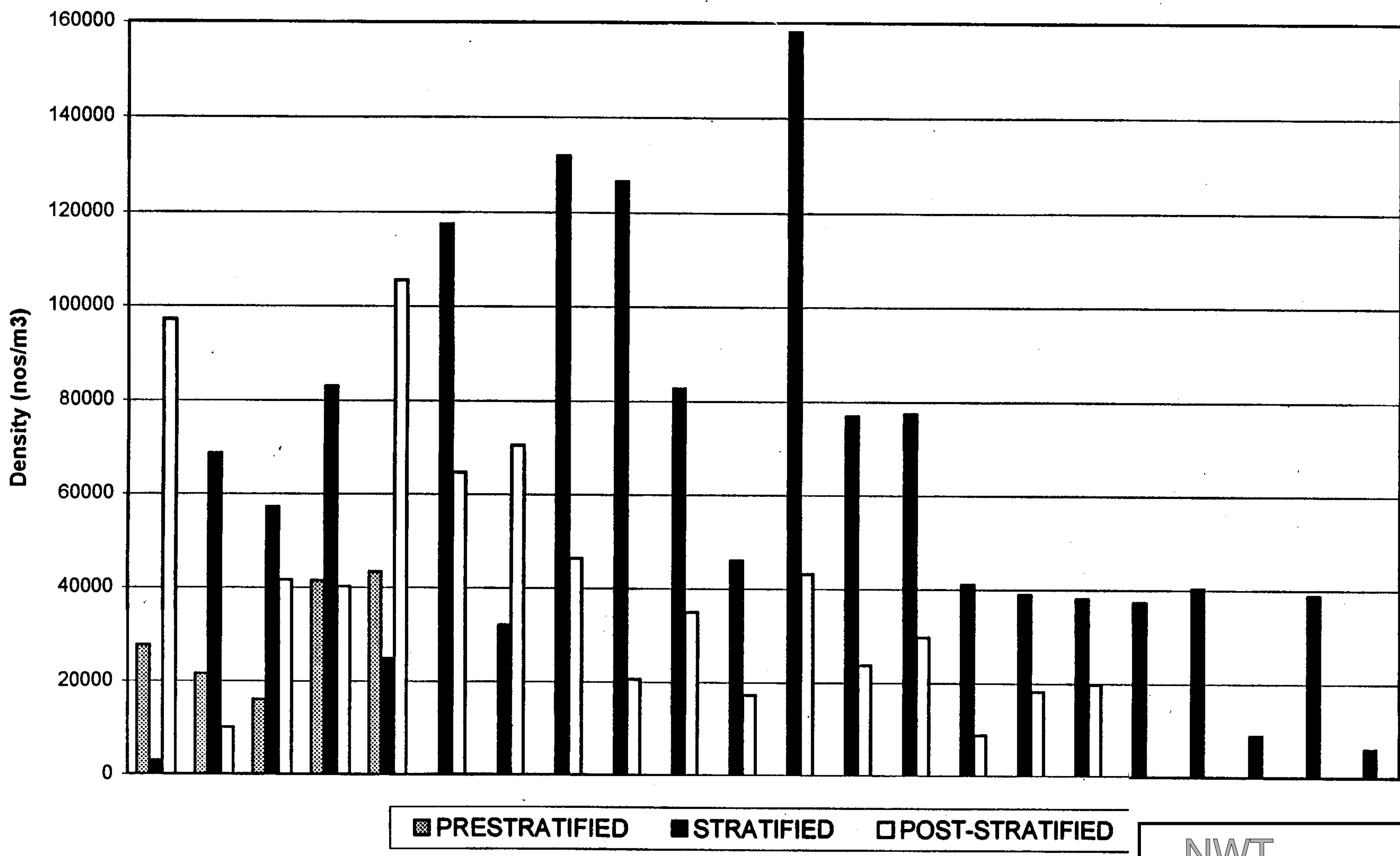

NWT DIAMONDS PROJECT

Figure 3.1-15
Zooplankton Density with Varying Stratification

Source: Rescan

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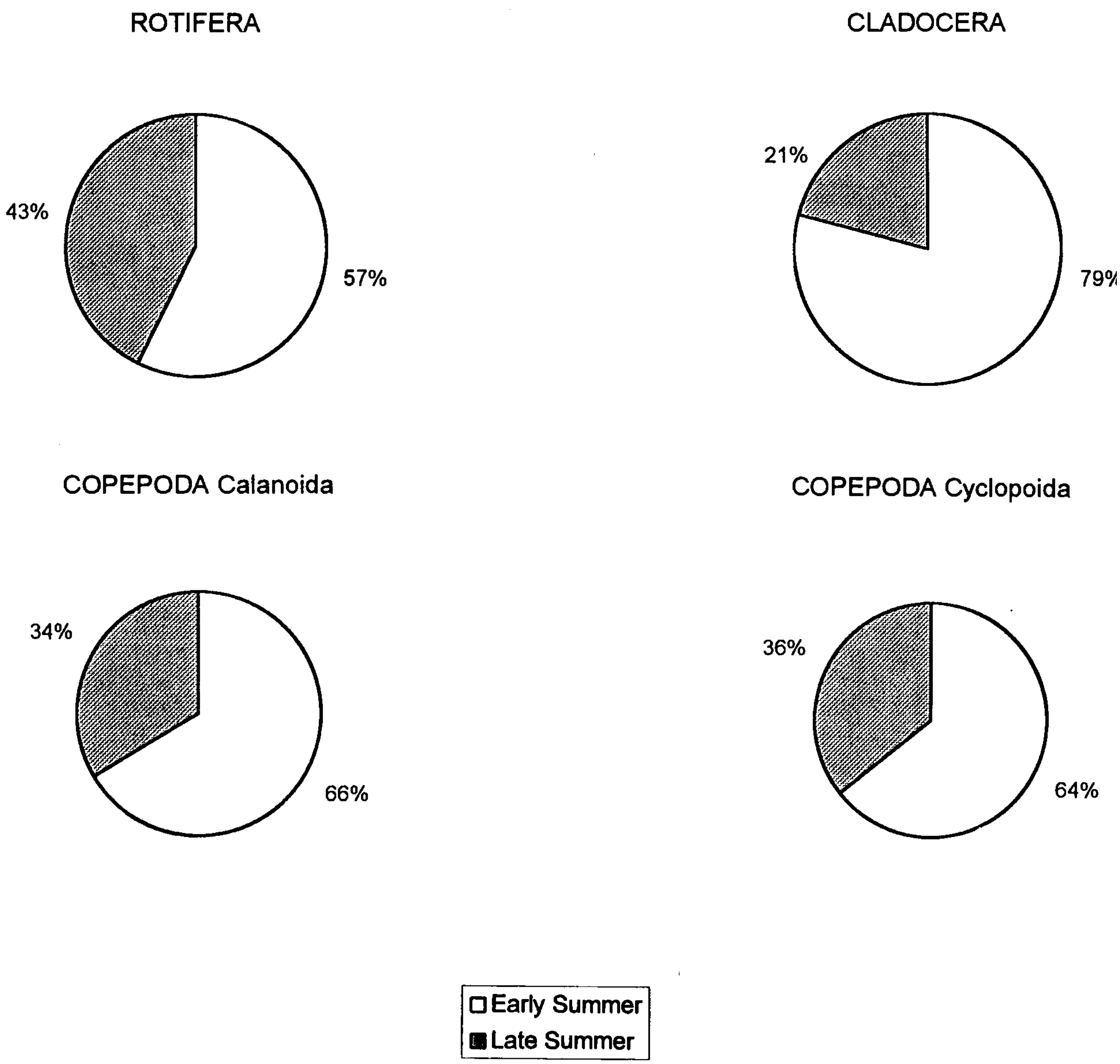

NWT DIAMONDS PROJECT

Figure 3.1-16
Percent Composition of Zooplankton, Summer 1994

Source: Rescan

major taxonomic groups of zooplankton and may have been partly due to fish predation. Of the four zooplankton groups, cladocerans are the most vulnerable prey since their movement is relatively slow.

As observed in other studies conducted in the subarctic (e.g., Hebert and Hann 1986) the calanoids were the dominant taxonomic group. *Diaptomus pribilofensis*, the most abundant species of zooplankton in this study, was also found to be dominant in a 1992 study of arctic lakes (Kling *et al*. 1992). Similarly, it was one of the three most common zooplankton species in subarctic lakes of the Yukon Territory (Shortreed and Stockner 1986) and the most common copepod in 45 Alaskan lakes (Kling *et al*. 1992). *Kellicottia longispina and Holopedium gibberum* (ranking highest in biological index values) were two of six species found to be most common and widespread in a study of 18 arctic and subarctic lakes (Moore 1978a). The average density of zooplankton in this study (47,484 individuals/m^3) was consistent with another Northwest Territories study which found an average density of 40,000 individuals/m^3 in Great Bear Lake (Johnson 1975).

A comprehensive list of the planktonic crustaceans present in Canadian lakes was published by the Department of Fisheries and Oceans (Patalas *et al*. 1994). The report maps the distribution of zooplankton species in Canada. Two Northwest Territories lakes included in the report were Courageous Lake (64°10'N 111°13'W) and Mathews Lake (64°04'N 111°14'W) both of which are located in close proximity to the Koala site (64°40'N 110°34'W). All the important species (those which comprised at least one percent of the total number of zooplankton individuals) found in the Koala Lake study were present in at least one of these two lakes. Five species found in the Koala study were not listed in either Courageous or Mathews lake: *Chydorus sphaericum*, *Epischura nevadensis*, *Eucyclops agilis*, *Cyclops capillatus* and *Cyclops vernalis*. However, these species occurred in such low numbers and were found at so few sites in the Koala study that they may have been too rare to be reported by Patalas *et al*. (1994).

3.1.2.4 Lake Benthos

Benthos, a general term for invertebrate organisms living on or in the bottom sediments, plays several important roles in the aquatic community. The objectives of benthic sampling were to document the taxonomic diversity and relative abundance of the benthos in the Koala region and to determine the effect of season, site and depth on the composition, abundance and richness of the invertebrate community. Given the sensitivity of the benthos to imposed changes, such a record provides a baseline against which future changes may be evaluated.

Previous Research

Moore (1978d) studied 20 arctic and subarctic lakes for benthic invertebrate communities between latitudes 62°N and 64°N. The closest study sites to the Koala watershed were two unnamed lakes between 64°05'N 111°08'W and 65°05'N 111°12'W, and Mathews Lake (64°04'N 111°14'W). These sites are within the Southern Arctic Ecozone, as is the Koala watershed. Studies were also conducted to determine the distribution and abundance of benthic invertebrates in the profundal zone of a northern lake (Moore 1981a). Hershey (1985) studied the effects of fish predation and habitat heterogeneity on benthic communities in an Alaskan lake (68°N). The studies mentioned are compared to the results of 1993 and 1994 studies conducted in the Koala and adjacent watersheds.

Methods

Preliminary lake benthos studies were conducted on eight lakes (Airstrip, Fox 1, Fox 2, Fox 3, Koala, Kodiak, Little, Long) between August 7 to 14, 1993 (Figure 2.4-1). In 1994, benthic grab samples were taken at 28 sites (Table 3.1-18; Figures 2.4-1 to 2.4-4) from five watersheds in each of two sampling periods, June 28 to August 5 (subarctic spring-summer) and August 12 to September 8 (summer-fall). At each site, three depths, shallow (1 m to 4 m), mid (4 m to 10 m) and deep (>10 m), were sampled in triplicate with an Ekman bottom grab (sample area = 0.0225 m^2). Each sample was transferred to a 595 µm mesh screen to remove excess sediment, followed by further sieving in a 250 µm screen. Material retained in the sieve was transferred to a 500 mL plastic jar and fixed in 10% buffered formalin.

Benthic invertebrate identification and enumeration were performed by Applied Technical Services, Saanichton, B.C. Samples were rinsed with water through a sieve series of 1,000 µm, 333 µm and 63 µm mesh size to remove the preservative and obtain three size fractions. From each fraction, organisms were counted and stored by major taxonomic groups. If large numbers of organisms of a particular type were present, the sample was sub-sampled by weight until a reasonable number of the group was counted (approximately 100). When all the samples had been sorted in the above manner, the organisms were identified to the species level, where possible and enumerated (Appendix II-B6).

Seasonal site parameters were calculated using the COMM program (Appendix II-B6) and included density, richness, number of taxa contributing to 90% of the density, diversity indices (Shannon and Simpson) and evenness indices (Pielou, Heip and Margalef). For both 1994 sampling periods, the COMM program was used to generate dendrograms showing the percentage similarity of 74 lake sites based on the abundance of 75 benthic taxa in the early summer period and 72 benthic taxa in the late summer period.

Table 3.1-18
1994 Site Numbers and Depths for
Lake Benthos Sampling in Five Watersheds

Site Number	Lake Station	Maximum Depth (m)
1	Lac de Gras (Northwest)	20
2	Mike	18
4	Martine	5
5	Fox 3	6
7	Fox 1	26
8	Nora	17
9	Slipper	16
10	Nero	14
12	Larry	8
14	Grizzly	40
15	Moose	8
17	Leslie	12
19	Long (South)	31
20	Long (North)	22
23	Little	19
25	Kodiak	12
27	Koala	18
29	Panda	17
32	Vulture	34
35	Ursula (East)	13
38	Sieve	9
44	Arnie	4
46	Mark	7
48	Misery	28
51	Bat	4
52	Paul (East)	12
53	Paul (West)	12
54	Lac de Gras (Misery Point)	30

In each lake, the sampled depths were determined to be either littoral or profundal zone samples. Secchi disc readings were recorded prior to sampling to enable calculation of the critical depth for each lake in each sampling period (Appendix II-B6).

ANOVAs were conducted on sampling season and lake zone data to determine differences in benthic density and whether diversity and evenness were a result of season or location within a lake (profundal *versus* littoral). ANOVAs were also conducted on benthic density and richness data to compare the Koala watershed with surrounding watersheds.

Separate and pooled variance t-tests were conducted to test the means of densities and richness for two lake zones (littoral and profundal) for the entire ice-free season. T-tests compared differences between sites and between the two zones for the following variables: benthic invertebrate density, richness (number of taxa per site) and community composition. The null hypotheses were designed to establish whether spatial (including lake location and sampling depth) and temporal variations affected community structure, density and richness.

Invertebrate data were also analyzed using principal component analysis (PCA) and a Pearson correlation matrix to determine which physical and chemical parameters contributed to the variation among sampled sites. Each site and corresponding depth in both sampling periods were compared with season, depth, critical depth, temperature, dissolved oxygen, site density, major taxonomic group densities, sediment metal concentrations and total organic carbon (Appendix II-B6). None of the physical and chemical parameters were found to cause significant variation in either analysis and, therefore, will not be discussed further.

Richness, Diversity and Community Similarity

A total of 58 taxa (excluding unidentified invertebrates) was recorded during the spring-summer study (Table 3.1-19), of which 14 were considered dominant, as their biological index values were greater than ten (Appendix II-B6). In the first sampling period, 54 littoral and 20 profundal zone sites were sampled in 25 lakes (Appendix II-B6). The total number of taxa recorded per site (richness) varied from six to 26 in the littoral and from five to 19 in the profundal. Average site richness was higher in the littoral zone (17 taxa) than the profundal zone (11 taxa), and density decreased from 5,372 individuals/m^2 in the littoral to 982 individuals/m^2 in the profundal.

Diptera dominated the taxonomic groups, comprising 64% (48 taxa) of the benthic fauna; Oligochaeta constituted 8% (six taxa), Trichoptera 5% (four taxa) and Ostracoda 4% (three taxa). Cladocera, Arachnida, Coleoptera and Mollusca each contributed 3% (two taxa each), and Coelenterata, Nematoda, Turbellaria, Eubranchiopoda and Harpacticoida each represented approximately 1% (one taxon each).

A total of 58 taxa was recorded during the summer-fall study (Table 3.1-19), of which 15 were considered dominant because they each had biological index values greater than ten (Appendix II-B6). During this later sampling period, 58 littoral and 16 profundal zones were sampled in the 25 lakes (Appendix II-B6). Site richness varied from six to 28 taxa in the littoral and from three to 17 taxa in the profundal. Average site richness was higher in the littoral than profundal zone

Table 3.1-19
Lake Benthos Identified from all Sites Sampled in the Koala and Adjacent Watersheds

Phylum	Class	Order	Family	Genus/Species	Summer 1993	Early Summer 1994	Late Summer 1994
ANNELIDA	OLIGOCHAETA		Enchytraeidae	unidentified		+	+
(segmented worms)	(roundworms)		Lumbriculidae	*Kincaidiana*	+		
			Lumbriculidae	*Limnedrilus*		+	+
			Naididae	*Nais*	+	+	+
			Tubificidae	*Rhyacodrilus*	+		
			Tubificidae	unidentified		+	+
				Vejdovskyella		+	+
				unidentified	+	+	+
ARTHROPODA	ARACHNIDA			*Acarina*		+	+
	(mites,spiders)			*Hydracarina*	+	+	+
				Oribatidae	+		
	INSECTA	COLEOPTERA		*Cybister*		+	
	(insects)	(water beetles)	Dytiscidae	*Brachyvatus*		+	+
		COLLEMBOLA (springtails)	Entomobryidae	unidentified	+		
		HEMIPTERA (water bugs)		unidentified		+	
		TRICHOPTERA	Hydroptilidae	*Agraylea*			+
		(caddisflies)	Leptoceridae	*Mystacides*		+	+
			Limnephilidae	*Grensia*		+	+
			Phryganeidae	*Agrypnia*			+
				Onocosmoecus			+
		LEPIDOPTERA (butterflies,moths)		unidentified			+
		DIPTERA	Chironomidae	*Chironomus*	+	+	+
		(true flies)	Chironomidae	*Conchapelopia*	+		
			Chironomidae	*Corynoneura*	+	+	+
			Chironomidae	*Corynocera*	+		
			Chironomidae	*Cricotopus*	+	+	+
			Chironomidae	*Demicryptochironomus*		+	+
			Chironomidae	*Dicrotendipes*	+	+	+
			Chironomidae	*Eukiefferiella*	+	+	+
			Chironomidae	*Gymnometriocnemus*		+	+

(continued)

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Table 3.1-19
Lake Benthos Identified from all Sites Sampled in the Koala and Adjacent Watersheds

Phylum	Class	Order	Family	Genus/Species	Summer 1993	Early Summer 1994	Late Summer 1994
ARTHROPODA	INSECTA	DIPTERA	Chironomidae	*Heterotanytarsus*	+		+
			Chironomidae	*Heterotrissocladius*		+	+
			Chironomidae	*Micropsectra*	+	+	+
			Chironomidae	*Microtendipes*	+	+	+
			Chironomidae	*Monodiamesa*	+	+	
			Chironomidae	*Pagastiella*			+
			Chironomidae	*Parachironomus*	+		+
			Chironomidae	*Paracladius*		+	
			Chironomidae	*Paracladopelma*		+	+
			Chironomidae	*Paramerina*	+	+	+
			Chironomidae	*Paraphaenocladius*		+	
			Chironomidae	*Paratanytarsus*	+		
			Chironomidae	*Parorthocladius*	+	+	+
			Chironomidae	*Phaenopsectra*	+	+	+
			Chironomidae	*Potthastia*		+	+
			Chironomidae	*Procladius*	+	+	+
			Chironomidae	*Protanypus*		+	+
			Chironomidae	*Psectrocladius*		+	+
			Chironomidae	*Pseudodiamesa*		+	+
			Chironomidae	*Rheotanytarsus*		+	+
			Chironomidae	*Stempellinella*		+	+
			Chironomidae	*Stichochirononmus*	+		
			Chironomidae	*Synorthocladius*	+		
			Chironomidae	*Tanytarsus*	+	+	+
			Chironomidae	*Thienemanniella*		+	
			Chironomidae	*Zalutschia*		+	+
			Chironomidae	unidentified	+	+	+
			Empididae	*Chelifera*		+	+
			Orthocladiinae	*Aspectrotanypus*	+		
			Orthocladiinae	*Brillia*	+		
			Simulidae	*Simulium*	+		
			Tipulidae	*Dicranota*			+
			Tipulidae	*Tipula*		+	
				Limnophora			+
				Oreogoton		+	
COELENTERATA (hydroids)				*Hydra*	+	+	+
CRUSTACEA	CLADOCERA (water fleas)		Chydoridae	*Alonella*		+	+
			Chydoridae	*Eurycercus*	+	+	+
			Macrothricidae	*Drepanothrix*	+		

(continued)

Table 3.1-19
Lake Benthos Identified from all Sites Sampled in the Koala and Adjacent Watersheds

Phylum	Class	Order	Family	Genus/Species	Summer 1993	Early Summer 1994	Late Summer 1994
	COPEPODA	Calanoida		*Diaptomus*	+		
		Cyclopoida		*Cyclops b. thomasi*	+		
		Cyclopoida		*Cyclops scutifer*	+		
	COPEPODA	Harpacticoida	Canthocamptidae	unidentified		+	+
				Canthocamptus	+		
	EUBRANCHIOPODA			*Triops*		+	
	OSTRACODA		Candoniidae	*Candona*	+	+	+
			Cyclocypridae	*Cyclocypris*	+		
				Cypria		+	+
MOLLUSCA	GASTROPODA (snails)		Valvatidae	*Valvata sincera*	+	+	+
	BIVALVIA (clams)		Sphaeriidae	*Pisidium*	+	+	+
				unidentified	+	+	+
	TURBELLARIA (flatworms)		Dalyellidae	unidentified		+	+
				unidentified	+		

with 18 and nine taxa per zone, respectively. Average site density was also lower in the profundal zone with 822 individuals/m^2, compared to 8,002 individuals/m^2 in the littoral zone.

Again, Diptera contributed the greatest number of taxa, comprising 61% (44 taxa) of the benthos; Trichoptera constituted 10% (seven taxa), Oligochaeta 8% (six taxa) and Ostracoda 4% (three taxa). Cladocera, Arachnida and Mollusca each contributed 3% (two taxa each) and Coelenterata, Nematoda, Turbellaria and Harpacticoida, Coleoptera and Lepidoptera each represented 1% (one taxon each).

In general, richness in taxa decreased with increasing water depth in both sampling periods (Figure 3.1-17). During the ice-free period, the richest sites (26 to 28 taxa per site) were found in Little (2 m), Kodiak (2 m), Paul (3 m), Vulture (4 m) and Martine (4.5 m) lakes. The lowest site richness (three to six taxa) were found in Koala (10 m, 18 m, 20 m), Fox 1 (26 m), Grizzly (4 m) and Nora (14.5 m) lakes.

Density and Relative Abundance

The maximum density recorded in 1994 was 6.4×10^4 individuals/m^2 in Bat Lake (3 m), the shallowest lake sampled. High densities (3.2×10^4 individuals/m^2 to 3.5×10^4 individuals/m^2), were also recorded in littoral zone sites from Kodiak (2 m, 3 m), Mark (3 m), Paul (3 m), Little (2 m) and Larry (2 m) lakes.

The lowest densities found in the profundal zone during the 1994 ice-free period (<400 individuals/m^2) occurred in Koala (10 m, 18 m, 20 m), Misery (22 m, 28 m), Fox 1 (26 m), Nora (14.5 m) and Grizzly lakes (43 m) presumably due to the depth of sampling. Sites with low littoral zone abundance included Ursula (7 m, 17 m, 17.5 m) and Long (4 m, 6 m) lakes.

In the summer study of 1993, the average site density was 4,955 individuals/m^2. Diptera dominated the benthic fauna, accounting for 67% of the total, followed by Nematoda (20%), Mollusca (5%), Oligochaeta (4%) and Copepoda (2%); Turbellaria and Ostracoda contributed to the remaining 2% (Figure 3.1-18).

In the spring-summer sampling, the average littoral zone density was 5,372 individuals/m^2 while the profundal zone density was 982 individuals/m^2. Diptera again dominated the benthic fauna, accounting for 47% of the total, followed by Nematoda with 31%, Mollusca with 15% and Oligochaeta with 5%; Ostracoda and Arachnida comprised the remaining 3% (Figure 3.1-18). In the summer-fall study, average density was 8,002 individuals/m^2 in the littoral zone and 822 individuals/m^2 in the profundal zone. Diptera comprised 63% of the total, followed by Nematoda with 14%, Mollusca 13%, Oligochaeta 7% and Ostracoda 2%; Arachnida, Coelenterata, Turbellaria, Copepoda, Cladocera, Coleoptera, Lepidoptera and Trichoptera contributed to the remaining 1% (Figure 3.1-18).

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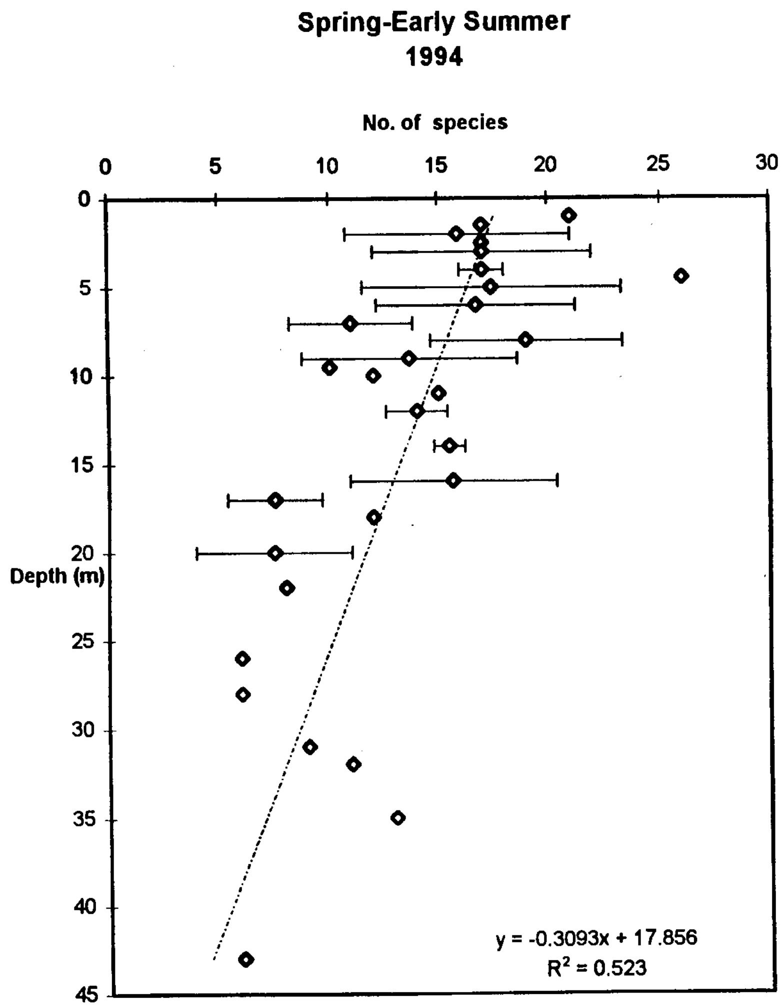
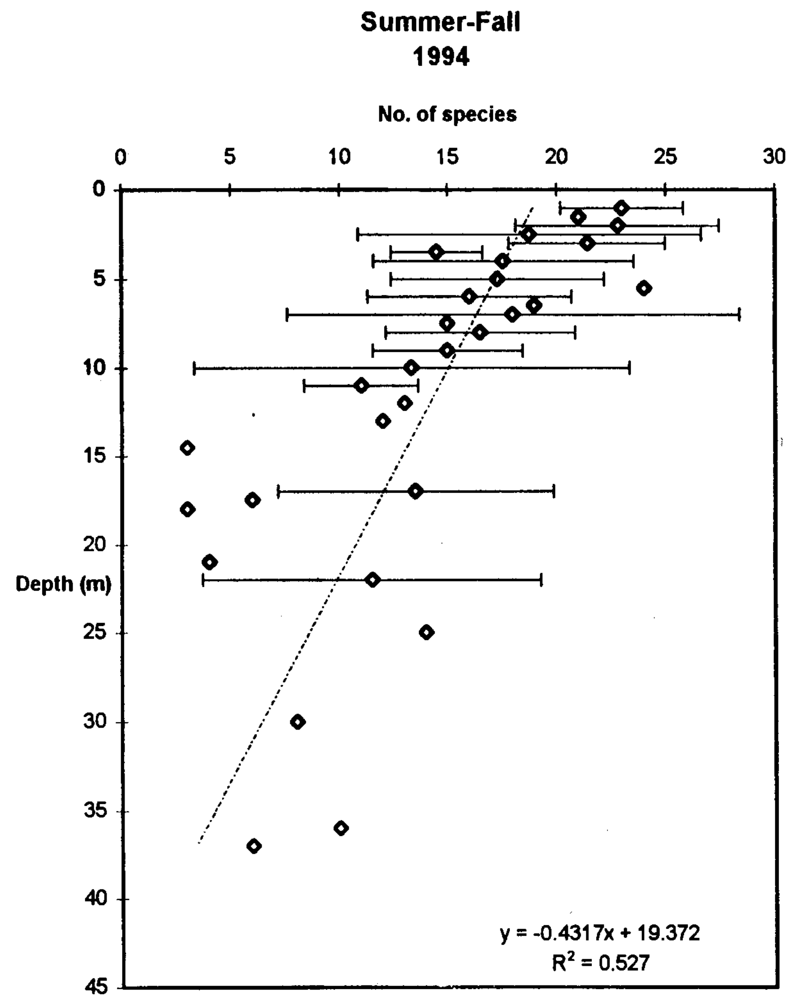


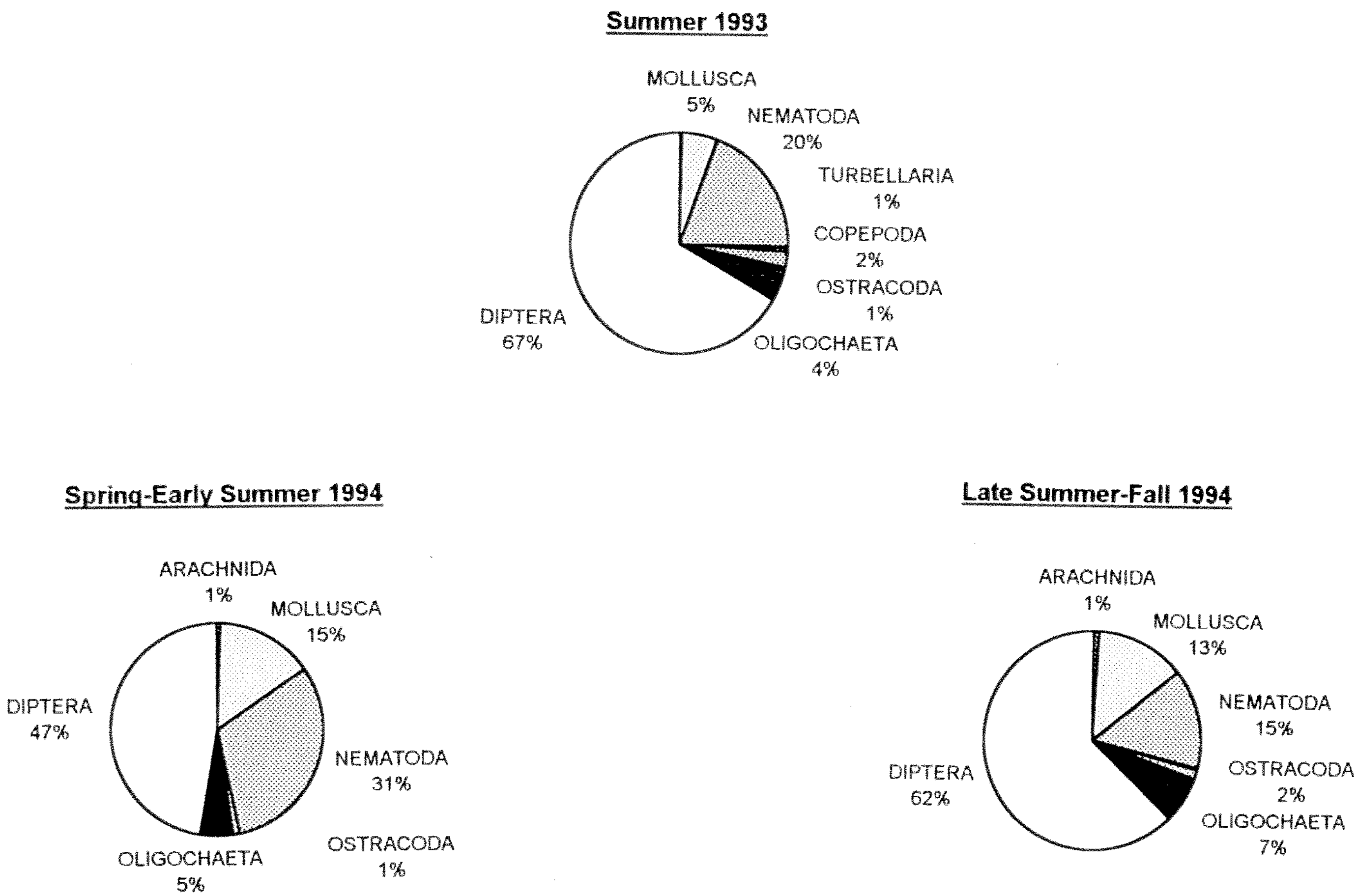


NWT DIAMONDS PROJECT

Figure 3.1-17
Number of Benthic Taxa *vs.* Depth for 1994

Source: Rescan

Cad No. a371s | Job No. 455 | 03/29/1994-05:22pm | Res_AV



NWT DIAMONDS PROJECT

Figure 3.1-18
Percent Composition of Benthic Invertebrates in Lakes

Source: Rescan

Seasonal abundances were not significantly different for the two lake zones. However, the littoral and profundal zones differed significantly with regard to benthic density when tested within each sampling period. There were no significant differences in density and richness between the Koala watershed and the surrounding watersheds. Diversity indices varied significantly spatially (i.e., between zones) and temporally (between seasons), however, evenness indices varied only spatially. Benthic density, richness and community composition were significantly different between the two zones (Appendix II-B6).

The seasonal dendrograms of sampled sites, using percentage similarity as the clustering criterion, are shown in Figures 3.1-19 and 3.1-20. There was no apparent clustering of sites based on location, depth or other physical characteristics. Percent similarity values among sites and depths in the early summer ranged from 47 to 88 and were lower than the later sampling period, which ranged from 80 to 97. The highest percentage similarity values were recorded for depths within the same lake, such as Mark Lake (Site 46) between 2 m and 7 m in the early summer and Koala (Site 27) between 10 m and 18 m, Nora (Site 8) between 4 m and 5 m and Ursula (Site 35) between 7 m and 17.5 m, in the late summer.

Benthic Invertebrate Communities

The structure of benthic invertebrate communities is determined by fish predation, water chemistry and the complexity of the environment (Jackson and Harvey 1993). In northern environments, trophic conditions limit both the density and diversity of benthos, ensuring that a small change in environmental conditions can have a marked effect on the bottom fauna (Moore 1978d).

The environmental conditions contributing most to the invertebrate community structure in the Koala region appear to be lake depth and the associated factor of thermal stratification. During the summer, the surface layer is considerably warmer than the deeper layer. This has a significant effect on the benthic community in terms of metabolic rate, the recycling of nutrients and nutrient exchange between layers.

Littoral Zone

Littoral zone primary and secondary production has often been found to dominate total lake production, especially in shallow lakes where a large fraction of the lake's surface area lies within the littoral zone (Stanford *et al.* 1983). The physicochemical features of the littoral regions of lakes are abundant light, surface warming, fluctuating water levels and wind-generated waves, which mix dissolved materials and disturb bottom sediments. Sediments are often graded, with the coarser materials at the lake's edge and finer particles in deeper water. Thus, littoral benthos, living in a structurally more complex habitat than profundal benthos, is often richer, or more diverse. In the present study, shallow depths

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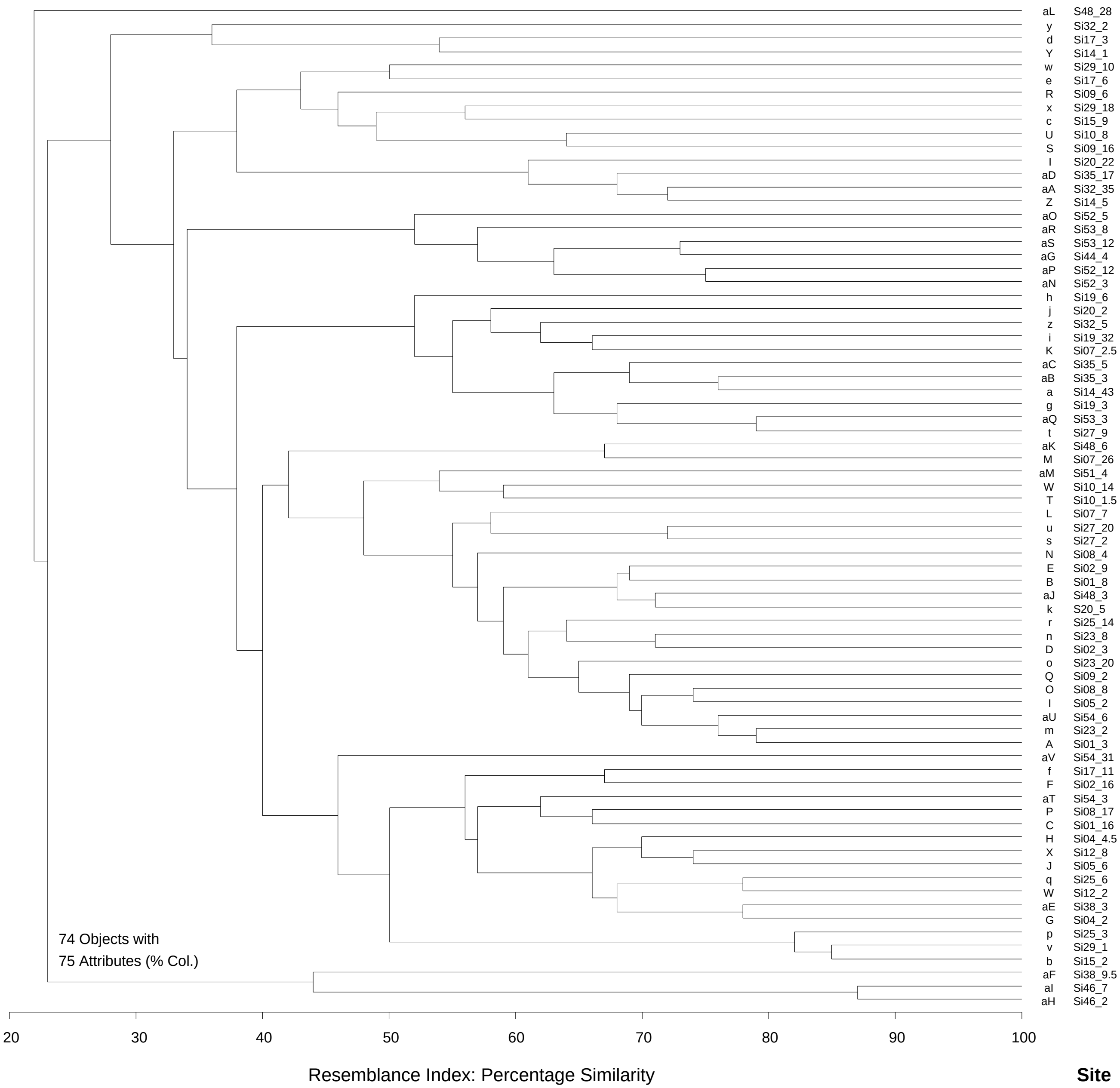

NWT DIAMONDS PROJECT

Figure 3.1-19
Spring-Early Summer Dendrogram for Lake Benthos

Source: Rescan

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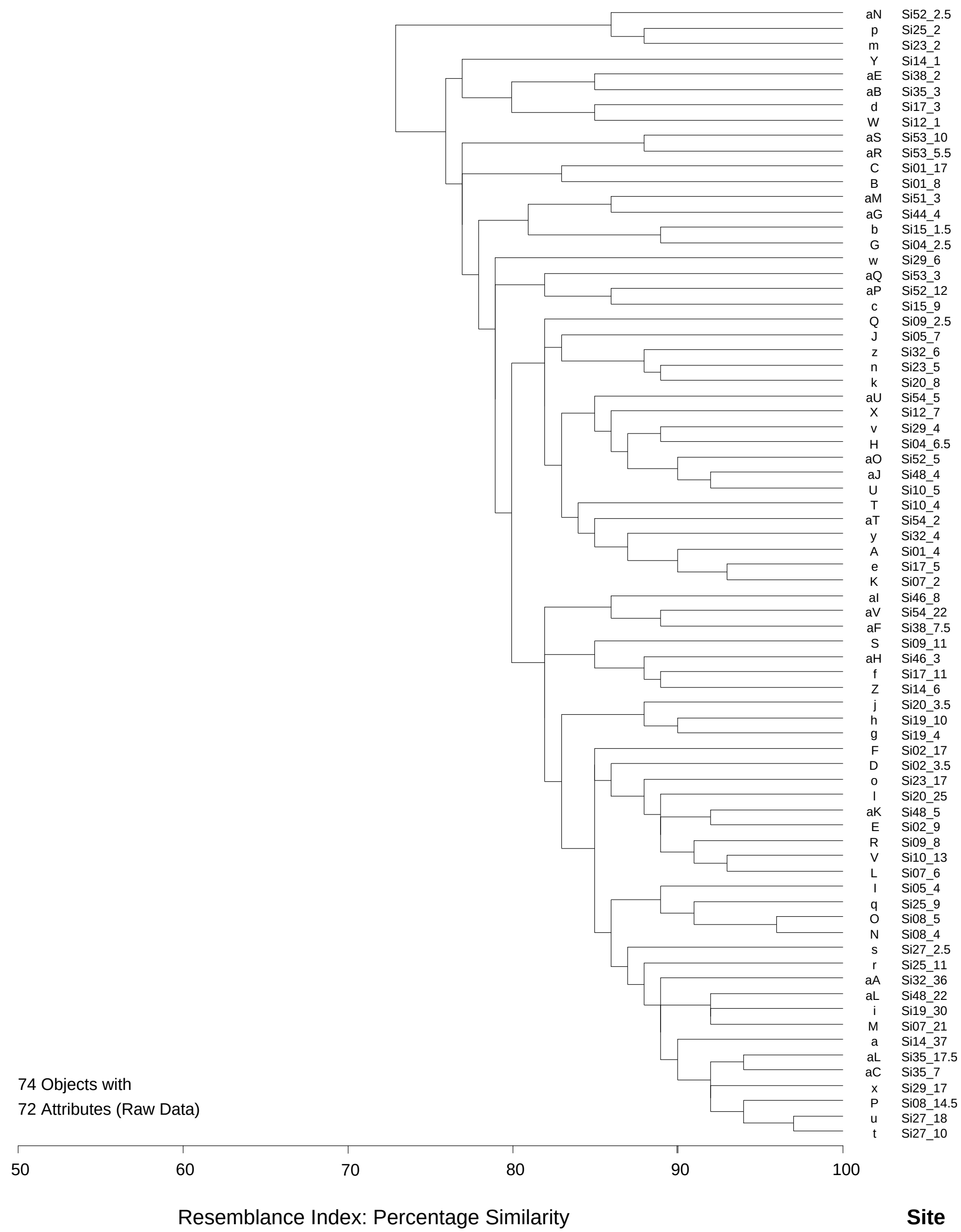

NWT DIAMONDS PROJECT

Figure 3.1-20
Summer - Fall Dendrogram
for Lake Benthos

Source: Rescan

were important habitats for the benthos, the greatest densities being recorded in a depth of 2 m to 3 m of water.

Fish are important components of littoral communities, often determining through predation, differences in density and composition of benthic invertebrates (Maitland 1990). Abundance of fish will be influenced by lake productivity *via* invertebrate productivity (Jackson and Harvey 1993; Hershey 1985). However, the effect of fish on invertebrate abundance is complex and difficult to predict due to a variety of direct and indirect interactions. Fish affect the benthos by direct predation or indirectly by reducing the relative abundance of zooplankton, thus allowing more phytoplankton and other detritus to settle on the bottom. Therefore, when fish density is high, predation rates may increase but so may the amount of settled food. Given the network of possible interactions between these two communities, it is difficult to predict the responses of many invertebrate taxa to changes in their chemical and physical environment (Jackson and Harvey 1993). A general shift to smaller-sized invertebrate taxa, reduced biomass and increased rates of benthic production is to be expected with increased predation by fish (Jackson and Harvey 1993).

Profundal Zone

The characteristic physicochemical conditions dominating lake profundal areas are the absence of light, long periods of low uniform temperature, fine sediments, lack of cover and amount of food available as plankton or detrital material (Brinkhurst 1974). The uniformity of the profundal region contributes to the significant decrease in benthic richness compared to the adjacent littoral zone. The benthos reaches its maximum density and diversity in shallow water and decline with increasing depth in the profundal zone. This pattern probably reflects gradients of habitat heterogeneity and food resources, all of which are greater in the littoral zone.

Phytoplankton is the primary source of food for the bottom fauna and its production is closely linked to the physical cycle of the lake. Phytoplankton is, of course, the primary food source but much of the benthos feeds on bacteria and the detrital remains of the phytoplankton. The problem of food supply is more complicated for profundal benthos, since food is produced in the upper few metres near the surface and consumed at the mud surface. Because there is minimal exchange of water between the upper and lower zones during stratification in the summer, phytoplankton reach the mud surface already partially decayed and thus, are an energy-poor nutrient source for the profundal organisms. Consequently, a general reduction of diversity with depth, as well as a reduction in density, may be attributed to a lack of quality food (Brinkhurst 1974).

Comparisons

Although there were significant differences between the two zones, percentage similarity values for the communities were quite high, most exceeding 50. The close groupings in these two sampling periods revealed the overall uniformity among sites sampled. The closer association of sites within the late summer period may be due to more uniform temperatures throughout the lakes, as the profundal zone temperatures increased throughout the summer season.

The density of benthos in most of the lakes was extremely low compared with populations in more temperate climates. For example, larval chironomids can achieve densities of 90,000 individuals/m^2 to 100,000 individuals/m^2 in lower latitudes (Wetzel 1975), compared with chironomid mean densities of 4,717 individuals/m^2 to 11,893 individuals/m^2 in the Koala region during the two sampling periods. The higher density of chironomids in the late summer sampling was possibly due to increased reproductive rates and an influx of newly recruited larvae.

In 20 arctic and subarctic lakes sampled between latitudes 62°N and 64°N, total abundance of benthic invertebrates generally varied from 200 individuals/m^2 to 4,000 individuals/m^2 (Moore 1978d), which is comparable to the overall density in the Koala region of approximately 1,000 individuals/m^2 in the profundal zone and 7,000 individuals/m^2 in the littoral zone during the 1994 ice-free season.

Summary

Field studies conducted in the Koala and adjacent watersheds indicate that larval drift and stream and lake benthic communities are dominated by insects. Insect dominance, primarily dipterans, increased as the ice-free season progressed. In 1994, larval drift densities decreased significantly as the summer season progressed, while stream benthos densities generally increased. Although peak discharge due to spring freshet occurred, stream benthic communities were similar over the ice-free period. Substrate type is an important variable determining invertebrate community structure in streams. In general, hard substrates had significantly higher density and richness in comparison to soft substrates over the entire 1994 sampling period. Although the densities of invertebrates may be high, the stream benthos is dominated by small forms such as nematodes and dipteran chironomids, and the biomass of invertebrates is low.

In all cases the lake benthos was dominated by small dipterans (mainly chironomids), nematodes and molluscs, and the overall biomass is low. The lakes in the Koala and adjacent watersheds were similar; however, within each lake there was a general reduction in benthic diversity and density with depth. The results of the lake benthos study showed that density, richness and composition were all directly influenced by available light and water temperature. By contrast, water depth, season, and spatial location were of comparatively little importance to the benthos.

Zooplankton were dominated by copepod and cladoceran crustaceans. It appears that phytoplankton density and temperature (stratification) may be significant factors regulating zooplankton abundance.

Certain characteristics of the secondary producers allow them to recover quickly from short-term disturbances with minimal effects. In particular, the mobility, short life cycles, high reproductive rates, and ability to encyst or burrow into the substrate allow stream and lake organisms to avoid or adjust quickly to regular variations in the aquatic environment (Minshall *et al.* 1985). Therefore, communities seem to be highly persistent (consistent within a given taxon) and resilient (they recover quickly).

3.1.3 Fish

Fish studies were conducted in 1993 and 1994 in the NWT Diamonds Project area. Fish are important indicators of the health of aquatic ecosystems as they are at the top of the food chain in aquatic environments. The objective of the study was to collect baseline data on fish abundance, distribution and habitat use, life history characteristics (age, growth, condition), feeding habits and trace metal tissue analyses. In addition, a mark-recapture program was initiated in 1994 on six study lakes (Panda, Koala, Long, Leslie, Fox 1 and Misery) to obtain population estimates and information on fish movement patterns.

The project is located in the Koala watershed at the headwaters of the Coppermine River, approximately 10 km north of Lac de Gras. The Koala watershed covers an area of 185 km^2 which is approximately 5% of the Lac de Gras watershed (3,980 km^2) and 0.4% of the Coppermine River watershed (50,800 km^2; Wedel *et al.* 1988). The relief of the area is very low, and the terrain is dominated by large boulders resulting in indistinct drainage patterns between lakes. Streams are ephemeral and the flow is often subsurface. The open water period lasts about three to four months (June to September).

Two fish species, lake trout and arctic grayling, are valued for food consumption. Lake trout is the dominant species in area lakes and is an important food fish. Arctic grayling is the main species inhabiting project area streams. There is no evidence of commercial or recreational use of fisheries resources within the project area. Aboriginal people have previously fished in the Lac de Gras region.

3.1.3.1 Previous Research and Traditional Knowledge

Fish have traditionally been an important food source harvested by Aboriginal people in the barren lands. Taken during both winter and summer, lake trout, whitefish and Arctic graying were a welcome addition to an otherwise steady diet of caribou. Fish, particularly whitefish, were also used to feed dogs when Dene and Inuit overwintered on the barrens, especially on the trap line. Small lakes and streams were rarely fished, however, and none were fished in the immediate vicinity of the project area. Rather, most fishing activities were concentrated at well-known sites on major lakes.

Locations where Dene and Metis fished in the Lac de Gras area and the region are provided in Appendix I-A1, Map Four, and Figure 3.1-21, respectively. In comparison with Contwoyto Lake and the area surrounding Desteffany Lake, the Lac de Gras area was not heavily fished by Aboriginal people (Figure 3.1-21).

Aboriginal knowledge of the species of fish they use for subsistence, relates to location, migratory behaviour (e.g., spawning runs), abundance and health (e.g. condition of internal organs):

"(Fish) travel through rivers and streams, but the lake where it was located at, it might want to go back to the lake that it was at in the first place. You know the wildlife cause you know (that) when people travel they always seem to want to go back where they originally were, and animals are probably the same..." (May Alonga, Coppermine).

The environmental baseline study represents the first detailed documentation of fish populations within the headwaters of the Coppermine River. However, studies have been conducted in the Izok Mine Site area, located in the Coppermine drainage, downstream of Lac de Gras. Fish studies have also been conducted at the Lupin Mine, approximately 100 km north of the project area in an adjacent watershed. Most information on freshwater fish indigenous to the NWT is focused on populations studied in Great Bear and Great Slave lakes, which are considerably larger lakes than those studied in the project area. Various studies have been done on fish populations in smaller lakes throughout the NWT. In addition, lake trout populations in northern Ontario, with similarities to the NWT, have been studied in great detail and provide valuable information.

Lake trout is widely distributed throughout the whole region. It is a cold-water species, preferring temperatures between 4°C and 12°C (Martin and Olver 1976). It is a slow growing fish, reaching maturity at six to 11 years in the northern part of its range (McPhail and Lindsey 1970). Lake trout spawn in autumn but timing depends on latitude, water temperature, photoperiod, weather, and the size and morphology of the lake (McIntosh 1994). In arctic lakes, most mature females spawn every two to three years (McPhail and Lindsey 1970). Spawning takes place primarily over rubble or gravel areas along lakeshores at depths of 0.3 m to 4 m in small lakes (Martin and Olver 1976). Embryo development takes place

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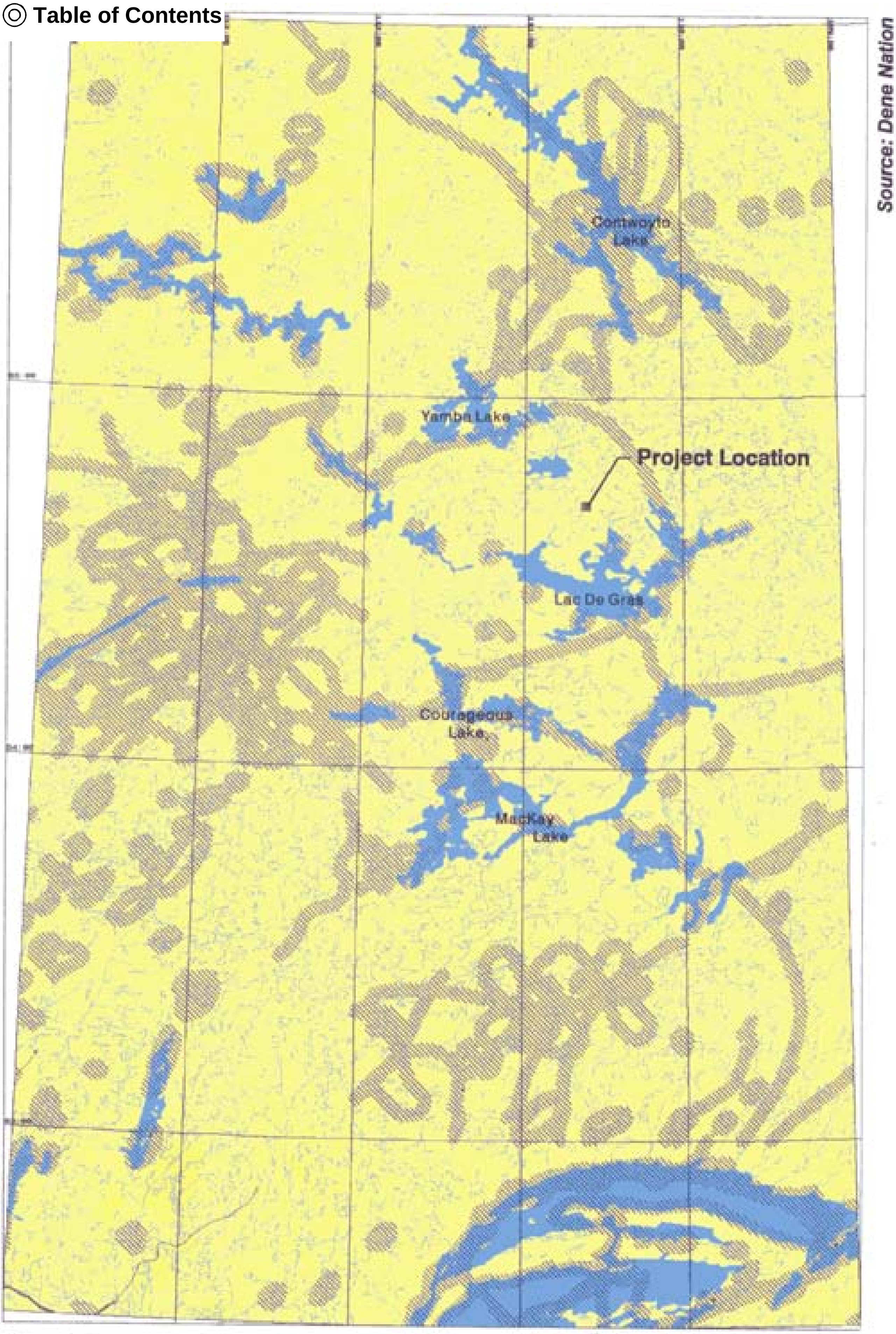

Figure 3.1-21

over winter, with hatching occurring the following spring during ice breakup. Lake trout are primarily piscivorous, feeding on cisco, whitefish and sticklebacks, aquatic invertebrates and terrestrial insects (McPhail and Lindsey 1970). Lake trout can become large, reaching 20 kg in many Canadian lakes, and are fished commercially and recreationally (Scott and Crossman 1973).

Arctic grayling are generally found in clear waters in northern lakes and streams, and are widely distributed throughout the NWT (McPhail and Lindsey 1970). Grayling spawn in small streams immediately following spring ice melt; this generally occurs from April to June in the subarctic region. Adults migrate from ice-covered lakes and large rivers to small gravel or rock-bottomed tributaries to spawn (Scott and Crossman 1973). Hatching takes place 16 to 18 days later when water temperatures reach 9°C. Arctic grayling feed primarily on terrestrial insects, amphipods and aquatic insects (McPhail and Lindsey 1970).

Round whitefish is mainly a northern species commonly found in the NWT and Alaska. They generally inhabit shallow areas of lakes and streams. They reach maturity by their sixth or seventh year in northern lakes (McPhail and Lindsey 1970). Spawning occurs in autumn over gravel substrate along lakeshores or in streams. Round whitefish feed on benthic invertebrates, especially mayfly nymphs, caddisfly and chironomid larvae and pupae, and small molluscs such as finger-nail clams and snails (Scott and Crossman 1973). They have also been reported to consume eggs of other species, including lake trout and suckers (McPhail and Lindsey 1970).

Burbot are widely distributed across the northern mainland but have not been recorded in the arctic islands or in the most northern parts of the central and eastern mainland. Burbot are often found in deep water in Great Slave Lake; they are common to depths of 100 m (McPhail and Lindsey 1970). Sexual maturity is usually attained by the third or fourth year (Scott and Crossman 1973). Burbot spawn in late winter under ice in streams or lake shallows, usually over a gravel substrate (McPhail and Lindsey 1970). Burbot feed primarily on fish including ciscoes, cottids, whitefish and sticklebacks (McPhail and Lindsey 1970). They also consume considerable quantities of mysids, amphipods and sphaeriid clams.

Longnose suckers are found in freshwater lakes and tributary streams throughout most of Canada and Alaska. In Great Slave Lake, longnose suckers were found to be sexually mature at nine years of age (Scott and Crossman 1973). Longnose suckers spawn over gravel in the spring, in streams or shallow areas of lakes. They enter spawning streams when water temperatures exceed 5°C (Scott and Crossman 1973). They are bottom feeders and their diet is composed principally of amphipods, midge larvae, caddisfly larvae and sphaeriid clams (McPhail and Lindsey 1970).

Slimy sculpin is a widespread forage species, found in lakes and streams. They are seldom over 6 cm in length and prefer rock or gravel substrates (Scott and

Crossman 1973). Slimy sculpin spawn in early spring usually in streams or in regions where some current exists as soon as the ice begins to melt. They feed on aquatic insects, crustaceans, small fishes and aquatic vegetation (McPhail and Lindsey 1970).

Lake chub is a large minnow with a very wide distribution. Lake chub are generally found in lakes and migrate into streams to spawn in summer (Scott and Crossman 1973). Terrestrial and aquatic insects, zooplankton and algae are their main food sources (McPhail and Lindsey 1970).

3.1.3.2 Methods

A brief description of the methods used during the 1994 field season is presented below. A detailed description of each method is presented in Appendix II-B7. Non-destructive sampling methods were used except where fish were intentionally retained for tissue sampling, age verification and identification purposes. Capture methods were selected to obtain representative samples in all size classes in different habitats.

Fish Habitat Assessment

Fish studies were conducted on 16 lakes and 15 streams (Figures 3.1-22 to 3.1-25). The sites selected for fisheries assessment will be directly or indirectly affected by mine development. Lakes that will be directly affected are open pit mine sites (Panda, Koala, Leslie, Fox 1 and Misery), a lake to be dewatered to access construction material (Airstrip) and the tailings disposal site at Long Lake. In addition, lakes downstream of directly affected lakes or lakes close to development areas were studied (Buster, Fox 2, Fox 3, Kodiak, Moose, Larry, Little, Nema, 1 Hump and Mark). Mike Lake was selected as a control site in the Koala watershed. Thirteen streams linking these lakes were also surveyed, as well as two control streams in the Ursula and South watersheds.

Stream surveys were conducted in streams with sufficient flow to allow for the use of conventional sampling methods. Streams were surveyed during freshet (June), summer (August) and fall (September). Parameters measured were adopted from the *Stream Survey Field Guide* (DFO and MOE 1989).

Lake habitat surveys consisted of water quality assessment, habitat mapping and spawning surveys. Substrate type was visually estimated from low altitude aerial observations and was ground-truthed at various sites. Lake trout spawning habitat was evaluated for each lake and optimal spawning habitat was mapped. Underwater lake trout spawning surveys were conducted mid-September in Panda, Fox 1 and Long lakes to identify important spawning areas.

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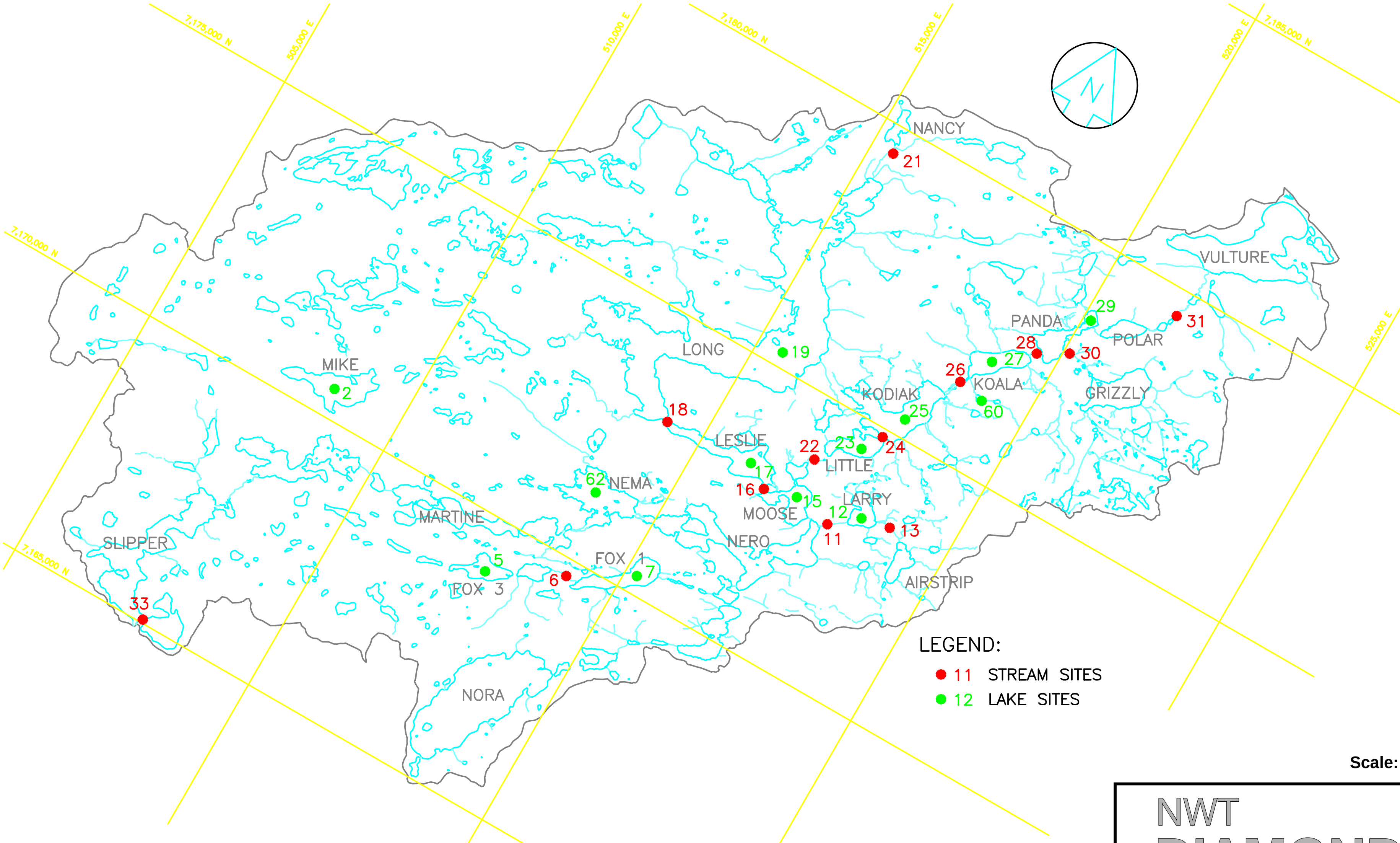

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NWT **DIAMONDS** PROJECT

Figure 3.1-22
Fish Study Locations -
Koala Drainage Basin, 1994

Source: Rescan

◎ Table of Contents

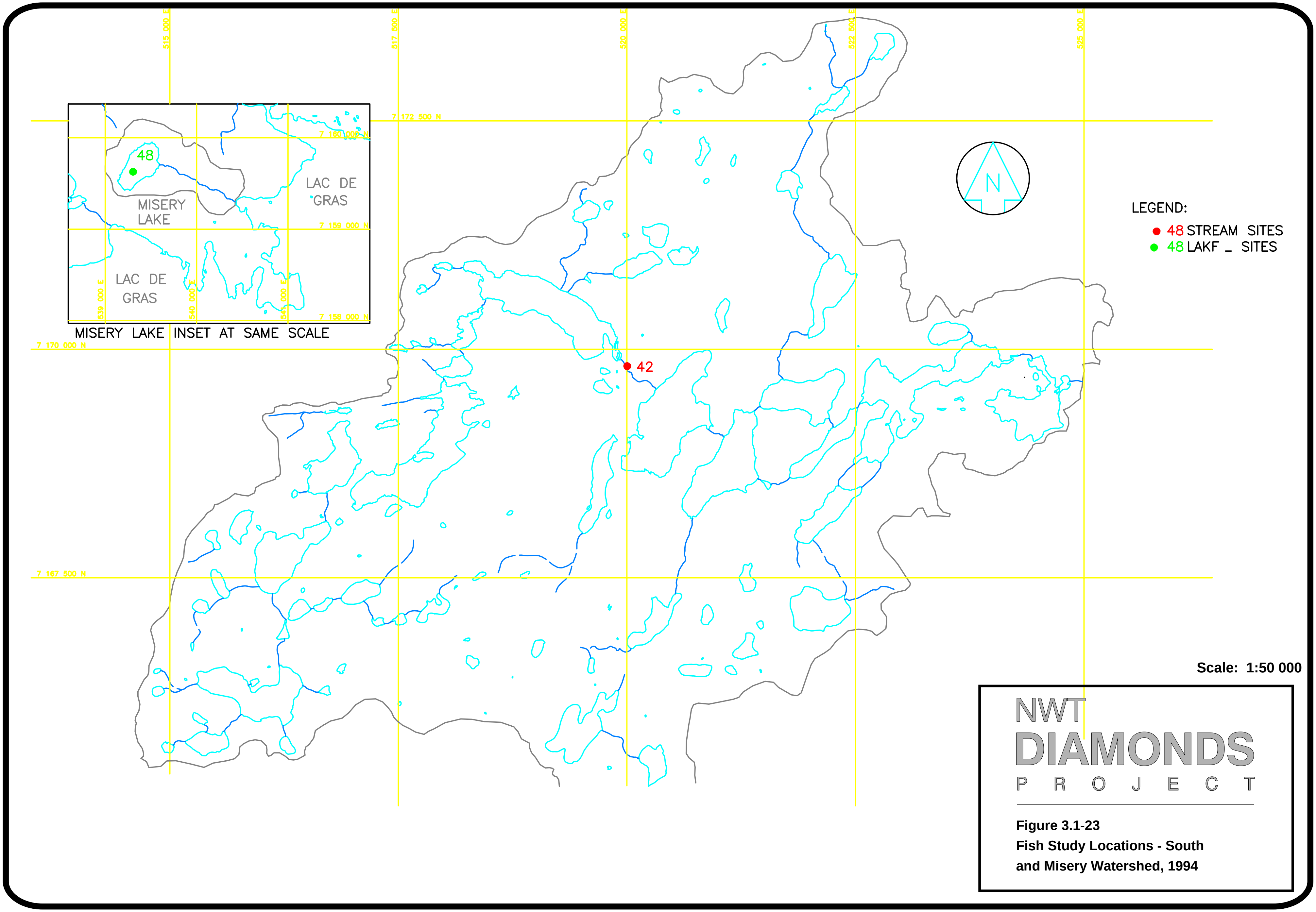
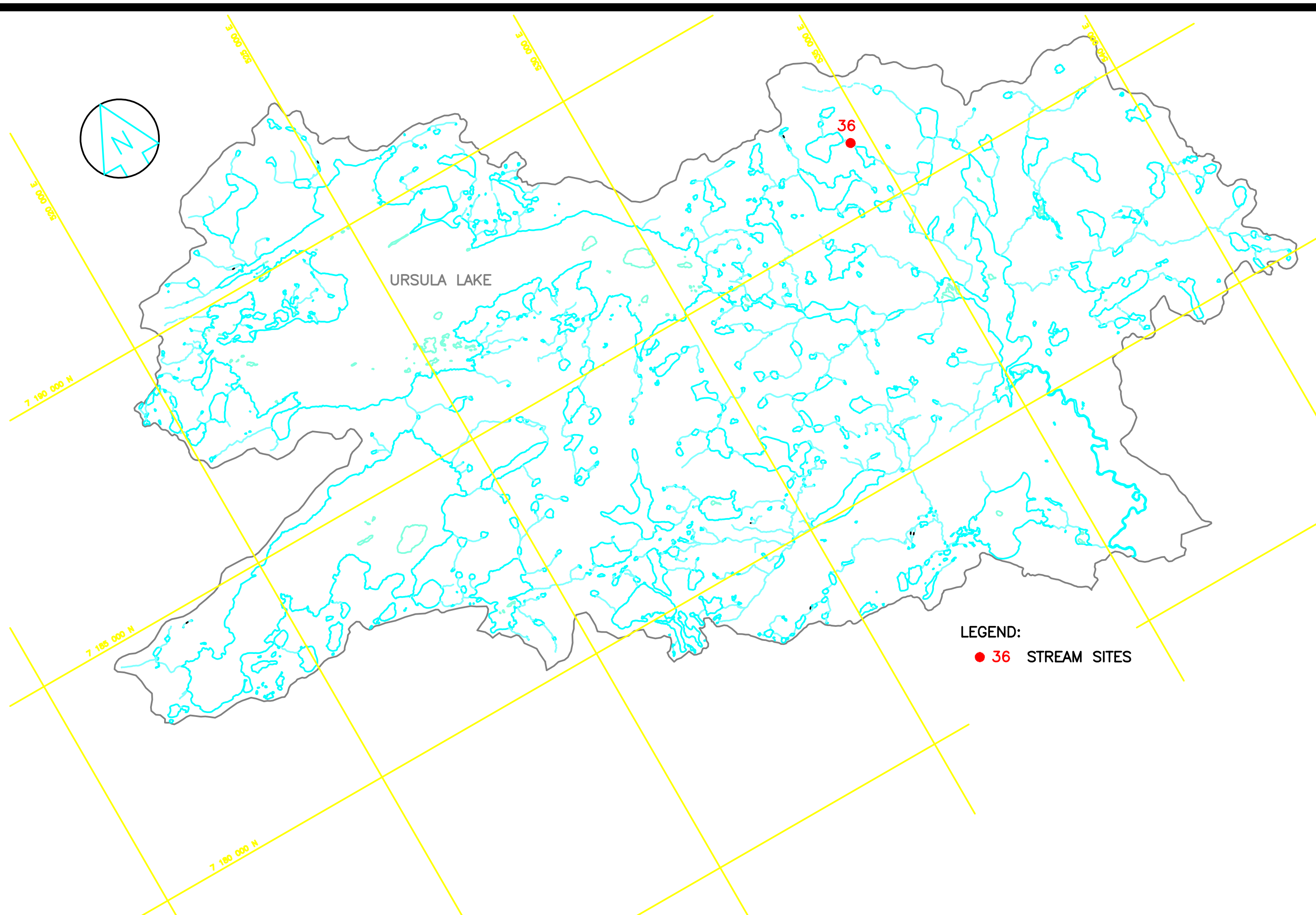


Figure 3.1-23
Fish Study Locations - South and Misery Watershed, 1994

Source: Rescan

◎ **Table of Contents**



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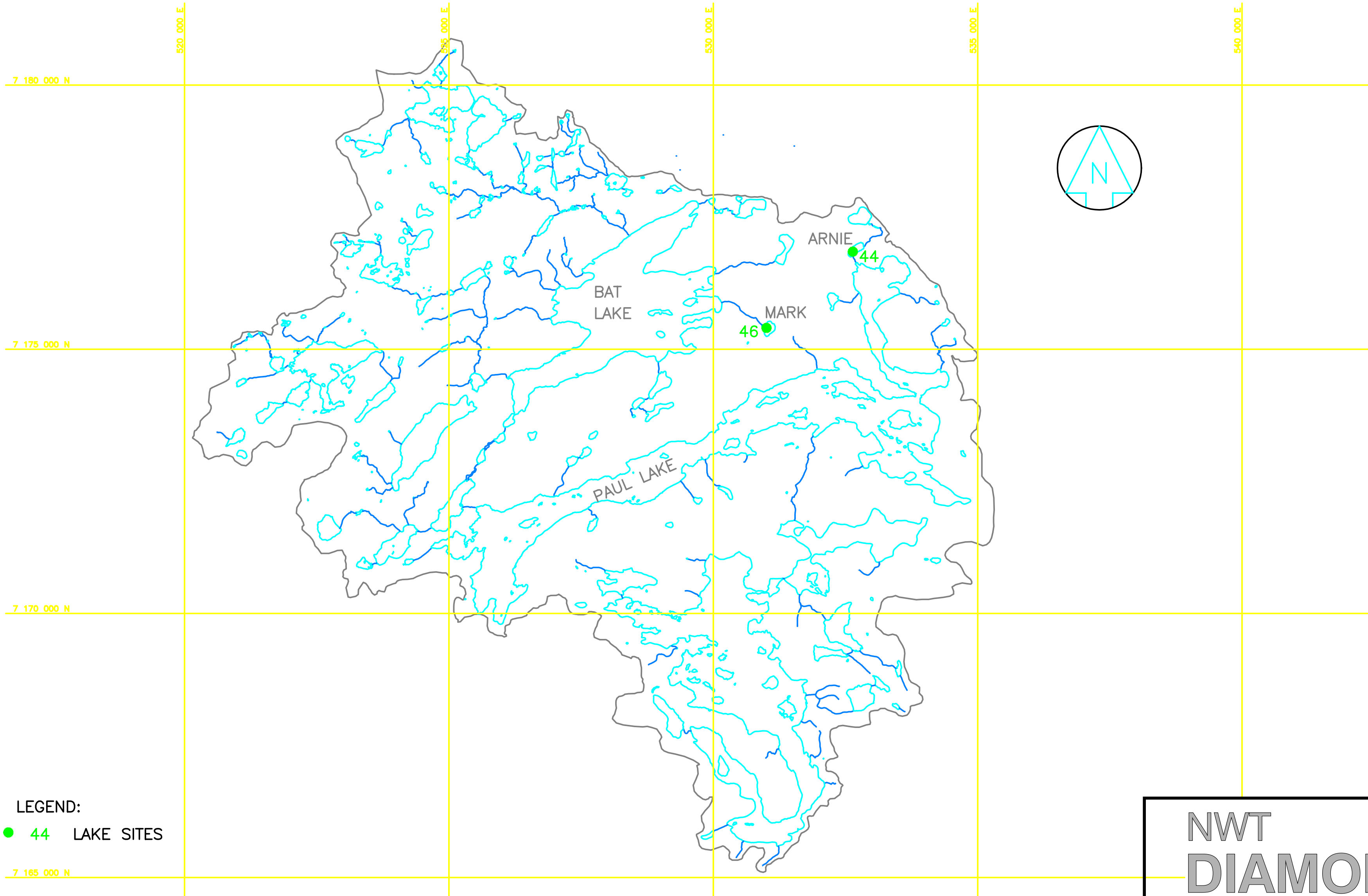
NWT DIAMONDS PROJECT

Figure 3.1-24
Fish Study Locations -
Ursula Drainage Basin, 1994

Source: Rescan

◎ Table of Contents



LEGEND:

● 44 LAKE SITES

Scale: 1:100 000

NWT
DIAMONDS
P R O J E C T

Figure 3.1-25
Fish Study Locations -
Paul Drainage Basin, 1994

Source: Rescan

Fish Collection Methods

A Smith-Root gas-powered backpack electroshocker was the primary method used to capture fish in streams. Small mesh gillnets (1.5" stretch) were used in streams where the water was too deep to electroshock (>1 m). Minnow traps baited with bread and salmon roe were set at multiple locations in streams. Dip nets were used to capture spawning fish and schooling fry. Samples of all fish species were collected and preserved for laboratory identification. Relative abundance of stream fish (expressed as a percentage of the total number caught) was determined for each stream for the three sampling periods.

From June to October 1994, 14 lakes were studied to provide comparative information on species abundance, population structure and trace metal content. The lakes were sampled using a combination of methods including day and night gillnetting, beach seines, baited minnow traps, trapnetting and angling.

Petersen's mark-recapture method, modified by Chapman (Ricker 1975) was used to obtain population estimates on the six lakes designated for mine development (Panda, Koala, Leslie, Fox 1 and Misery). Fish having >300 mm fork length were tagged with a numbered Floy tag and released. The population size is based on the proportion of marked (tagged) to unmarked fish caught within a closed population (no immigration or emigration). Therefore, the population estimate is based on the portion of the fish population >300 mm.

Stomach samples were collected from specimens representing a wide range of size and age classes for each species. Fish stomachs were collected from those that died during sampling and from recreational angling. Samples were preserved in 10% phosphate-buffered formalin and then submitted for analysis.

Age Determination and Verification

Left pectoral fin rays were used to age lake trout, burbot and longnose suckers. Round whitefish were aged by scales and arctic grayling were aged by scales and fin rays. Since most fish were released alive, more scales and fin rays were collected than otoliths. Otoliths provide more accurate ages for slow growing arctic fish but the number of otolith samples was restricted by sampling mortality (Healey 1978b). Aging structures were analyzed by Inuvik Fisheries Consulting and Age Laboratory in Inuvik, NWT, using appropriate laboratory techniques for each procedure.

To verify ages determined from scales and fin rays, direct comparisons were made with ages determined from otoliths. Comparisons were made for each fork length class (5 cm or 10 cm, depending on sample size) to determine if the reliability of age estimates from scales and fin rays, is affected by fish size. In addition, 5% of aging samples were sent to an independent aging laboratory for verification.

Trace Metal Analysis

In order to document background levels of metallic trace elements in fish, samples of dorsal muscle and liver tissue were taken from specimens over a wide range of sizes and ages. A total of 13 trace metals was analyzed including: arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, selenium, silver and zinc. Of these, only mercury may bioaccumulate to cautionary levels in large, old predatory fish. The tissues were extracted in a clean environment, then individually wrapped in Whirlpak® bags and frozen until submission for analysis (within one month of capture).

3.1.3.3 Fish Habitat

Fish habitat was described for 15 lakes and 15 streams in the study area. Streams provide spawning habitat for mature arctic grayling and nursery areas for juvenile arctic grayling, burbot and slimy sculpin. Longnose suckers reportedly use streams for spawning and rearing, but were rarely observed in the streams surveyed. Streams also serve as migration routes for most species.

Most streams in the study area were characterized by predominantly boulder substrate, indistinct drainage patterns, shallow slope gradients and subsurface flows. Habitat characteristics of streams surveyed during the 1994 field season are presented in Appendix II-B8. Two streams (Fox 1-Fox 2; Larry-Nero) were not surveyed in August and September due to very low water levels. The Misery-Lac de Gras stream was designated for sampling in August; however, most of the water flow was subsurface to allow for adequate sampling. This stream will be sampled during the freshet period of 1995.

The relief in the project area is very low, resulting in diffuse flow patterns. Some streams such as Panda-Koala, Nancy-Long, Leslie-Moose have distinct channels. Generally stream gradients are very low. The average gradient between Vulture Lake and Lac de Gras is approximately 0.3%.

Flow rates varied greatly between seasons and many streams had little to no surface flow after freshet subsided (i.e., Fox 1-Fox 2 and Little-Moose). Flow in some streams was mainly subsurface for the entire ice-free season. For the purpose of assessing the suitability of streams for fish, the value of fish habitat largely depends upon the amount of surface area remaining during the driest period.

During freshet, high water levels and flow rates increased the percentage of runs and riffles in the streams. Most streams had sufficient flow to support adult fish during the freshet period and allow migration of adult fish between lakes. After freshet, water flow was considerably lower and most streams consisted of pools with occasional riffles. In the fall, only isolated pools remained and water flow was minimal. At this time, small fish began to migrate from streams to lakes to over-winter.

Only the streams that connect lakes within main drainages maintained enough flow to allow migration. For example, one adult grayling tagged in Koala Lake in mid-June was later recaptured in late-August at the top end of Panda Lake (the lake immediately upstream). Although lake trout do not usually enter streams, one adult lake trout was captured in Panda-Koala stream in late-June after spring discharge had subsided. A better understanding of migration between lakes will be obtained from future mark-recapture surveys.

Streams were generally well-oxygenated with dissolved oxygen levels ranging from 7.3 mg/L to 15.5 mg/L over the field season. The pH levels in streams sampled ranged from 5.2 (Airstrip-Larry) to 8.1 (Vulture-Polar) and most were within guidelines for aquatic life (CCREM 1987). Stream temperatures ranged from a low of 4°C during freshet to a high of 17°C in the summer.

Stream cover provides shade and protection from predation for small fish. Cover in the NWT Diamonds Project streams consists mainly of boulders and pools. There is minimal organic debris (i.e., wood and vegetation) and undercut banks, since aquatic vegetation is sparse. A few streams have overhanging vegetation, (i.e., Little-Moose, Airstrip-Larry, and South) dominated by dwarf birch and willow shrubs.

Lake Habitat

Lakes provide feeding, rearing and over-wintering habitat for all fish species. In addition, most lakes in the project area provide spawning habitat for lake trout, round whitefish, burbot and possibly longnose sucker. As lake trout dominate lake ecosystems and have the highest value among the species present, greater emphasis was placed on their habitat.

Lakes in the region are relatively young, having formed 8,000 years to 12,000 years ago since the retreat of the last Pleistocene glaciation. Since that time, they have remained undisturbed by human activity. The lakes for fisheries studies range in size, with Buster Lake being the smallest (1 ha) and shallowest (5 m) and Long Lake the largest (614 ha) and deepest (34 m). Based on nutrient levels and primary productivity, most of the lakes are classified as oligotrophic (unproductive, clear, cold waters; Dillon and Rigler 1975).

An important climatic factor in these northern lakes is the annual formation and melting of ice cover. Ice begins to break up in late May and generally melts from most lakes by the second week of June. Larger lakes tend to be ice-free somewhat later. For example, Long Lake is usually not free of ice until the end of June. The period of open water lasts about 3 months to 4 months.

Surface water temperatures continually increase during the ice-free period and reach a maximum of approximately 17°C during mid-August. Temperatures decrease rapidly in September as water mixing occurs throughout the lakes. Thermoclines, rapid declines in temperature with depth, developed in mid-summer 1994 in approximately half of the lakes sampled. Thermoclines create stability and restrict water circulation in surface waters, thus, often decreasing dissolved oxygen concentration in the lower levels. Despite the formation of thermoclines in many lakes, oxygen levels remained quite high throughout the open water period. Optimal fish habitat volumes are likely to be more restricted by thermal regimes than oxygen levels.

Freeze-up occurs in late September in the smaller lakes and mid-October for larger lakes. During winter, water temperatures vary between 0°C directly below the ice to 4°C in deeper water. Ice reaches a maximum thickness of 2 m to 3 m in winter, reducing habitat area. For example, in Koala and Kodiak lakes ice coverage reduces the water volume by 28% and 48%, respectively.

Substrate type is another important determinant of habitat suitability for various fish species. Bottom substrate largely determines such activities as feeding and spawning. Substrate type is similar among lakes, with rocky shorelines giving way to littoral zones of boulder and cobble, followed by silt at greater depths. Larry Lake was the only study lake with abundant sandy areas in the littoral zone.

Lake trout often spawn in sites which are used year after year (Martin 1960; Ball 1988). They do not form redds (gravel mounds in which the eggs are buried after fertilization) as do most other salmonid species, but scatter their fertilized eggs widely over a clean, coarse substrate with sufficient interstitial spaces to protect the eggs from predators.

Within each lake, the area suitable for lake trout spawning was evaluated and optimal spawning habitat was mapped (Figures 3.1-26 to 3.1-40). This evaluation was based on the following criteria, developed from detailed lake trout spawning studies (Rawson 1961; Martin and Olver 1980; MacLean 1990; McMurtry 1986; SENES and TAEM 1991):

- *Substrate*: clean coarse substrate, clear of detritus and usually mixed with boulders and patches of gravel

- *Water depth*: 2 m to 4 m

- *Wind exposure*: high exposure to prevailing winds and wind driven currents, e.g., at shoreline outcroppings, offshore reefs or along windward side of islands

- *Bottom contours*: usually found near areas of steep drop-offs and often associated with terrestrial shorelines with bare rock faces.

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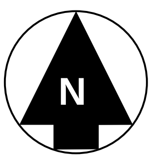
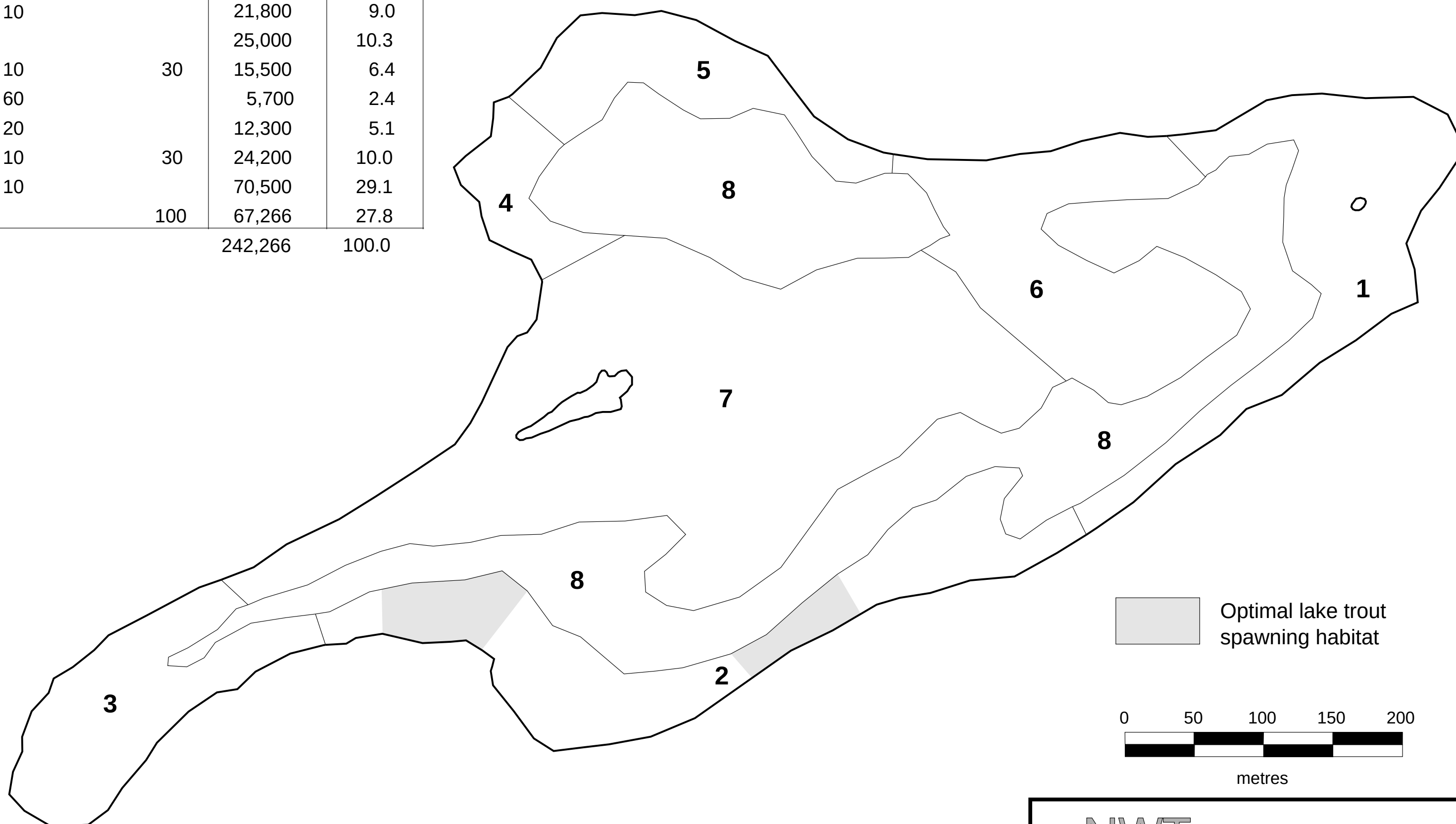
Lake	Total Area (m^2)	Habitat Zone	Substrate Type Boulder (%)	Cobble (%)	Gravel (%)	Fines (%)	Habitat Area (m^2)	Percent Area (%)
Fox 3	242,266	1	90	10			21,800	9.0
		2	100				25,000	10.3
		3	60	10		30	15,500	6.4
		4	40	60			5,700	2.4
		5	80	20			12,300	5.1
		6	60	10		30	24,200	10.0
		7	90	10			70,500	29.1
	Basin	8				100	67,266	27.8
							242,266	100.0





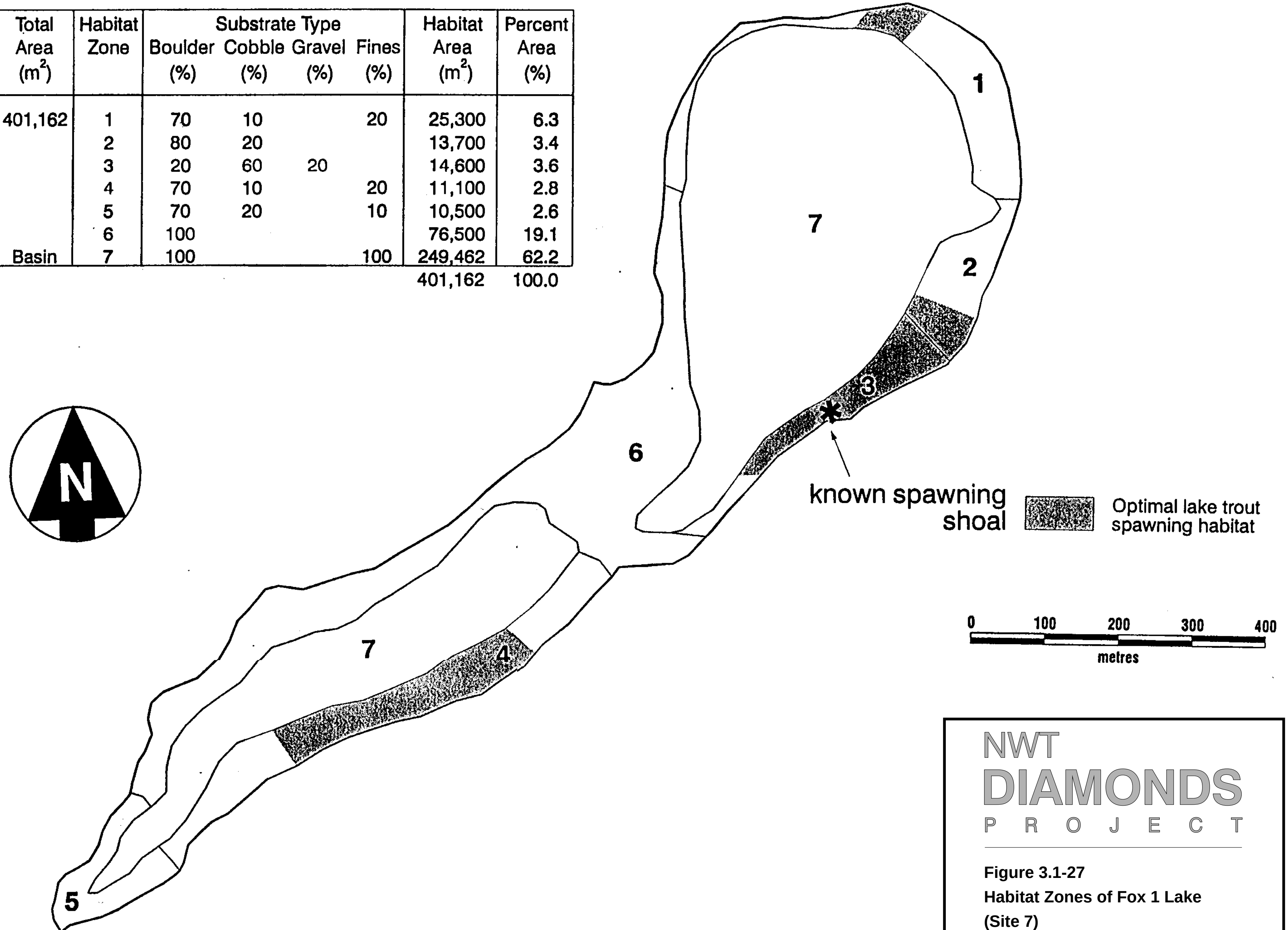
NWT DIAMONDS PROJECT

Figure 3.1-26
Habitat Zones of Fox 3 Lake
(Site 5)

Source: Rescan

◎ Table of Contents

Lake	Total Area (m²)	Habitat Zone	Substrate Type Boulder (%)	Cobble (%)	Gravel (%)	Fines (%)	Habitat Area (m²)	Percent Area (%)
Fox 1	401,162	1	70	10		20	25,300	6.3
		2	80	20			13,700	3.4
		3	20	60	20		14,600	3.6
		4	70	10		20	11,100	2.8
		5	70	20		10	10,500	2.6
		6	100				76,500	19.1
	Basin	7	100			100	249,462	62.2
							401,162	100.0

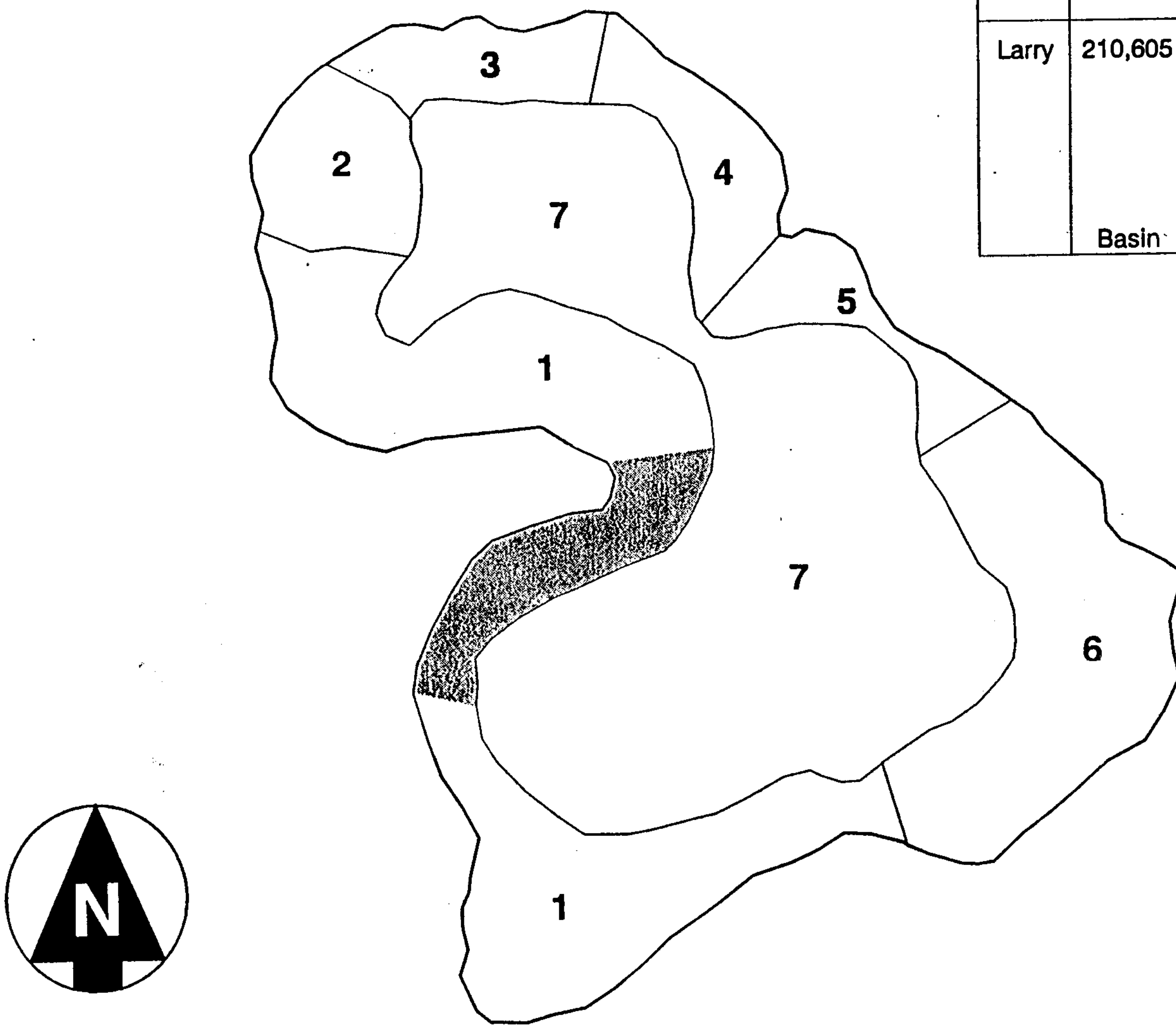


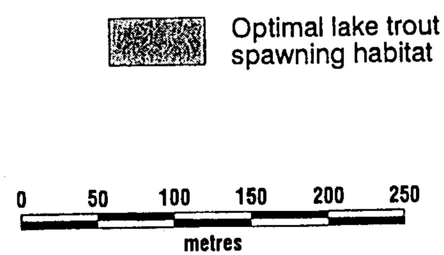
NWT DIAMONDS PROJECT

Figure 3.1-27
Habitat Zones of Fox 1 Lake
(Site 7)

Source: Rescan

Lake	Total Area (m^2)	Habitat Zone	Substrate Type Boulder (%)	Cobble (%)	Gravel (%)	Fines (%)	Habitat Area (m^2)	Percent Area (%)
Larry	210,605	1	100				57,000	27.1
		2	40	30		30	9,500	4.5
		3	90	10			7,100	3.4
		4	50	10		40	9,100	4.3
		5	20	10		70	7,300	3.5
		6	10			90	28,200	13.4
	Basin	7				100	92,405	43.9
							210,605	100.0





NWT DIAMONDS PROJECT

Figure 3.1-28
Habitat Zones of Larry Lake
(Site 11)

Source: Rescan

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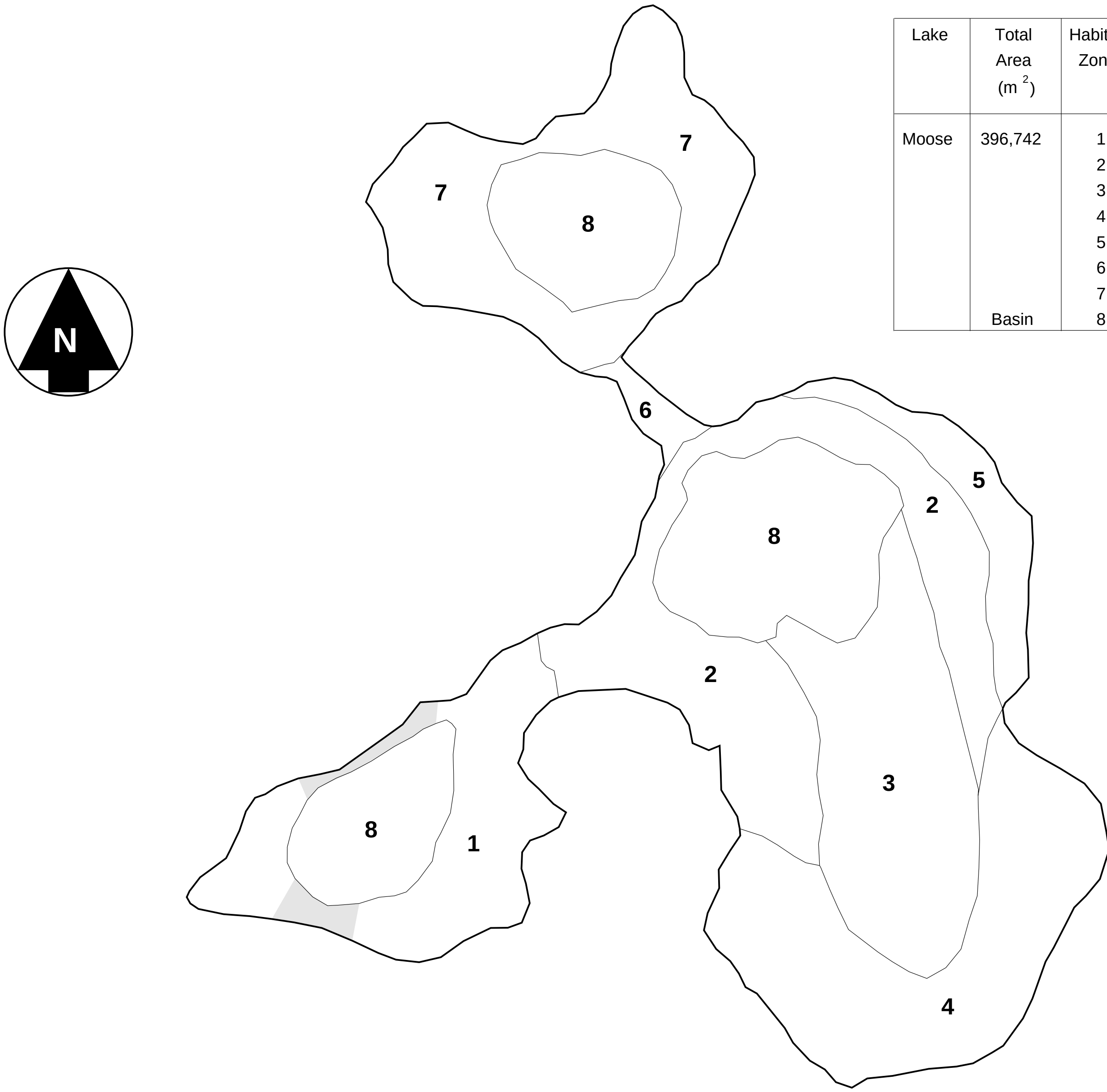


Lake	Total Area (m^2)	Habitat Zone	Substrate Type: Boulder (%)	Cobble (%)	Gravel (%)	Fines (%)	Habitat Area (m^2)	Percent Area (%)
Moose	396,742	1	10	70		20	65,600	16.5
		2	10	10		80	64,600	16.3
		3	10			90	55,400	14.0
		4	40	60			66,000	16.6
		5	100				16,300	4.1
		6	100				4,200	1.1
		7	50	50			79,000	19.9
	Basin	8				100	45,642	11.5
							396,742	100.0

Optimal lake trout spawning habitat

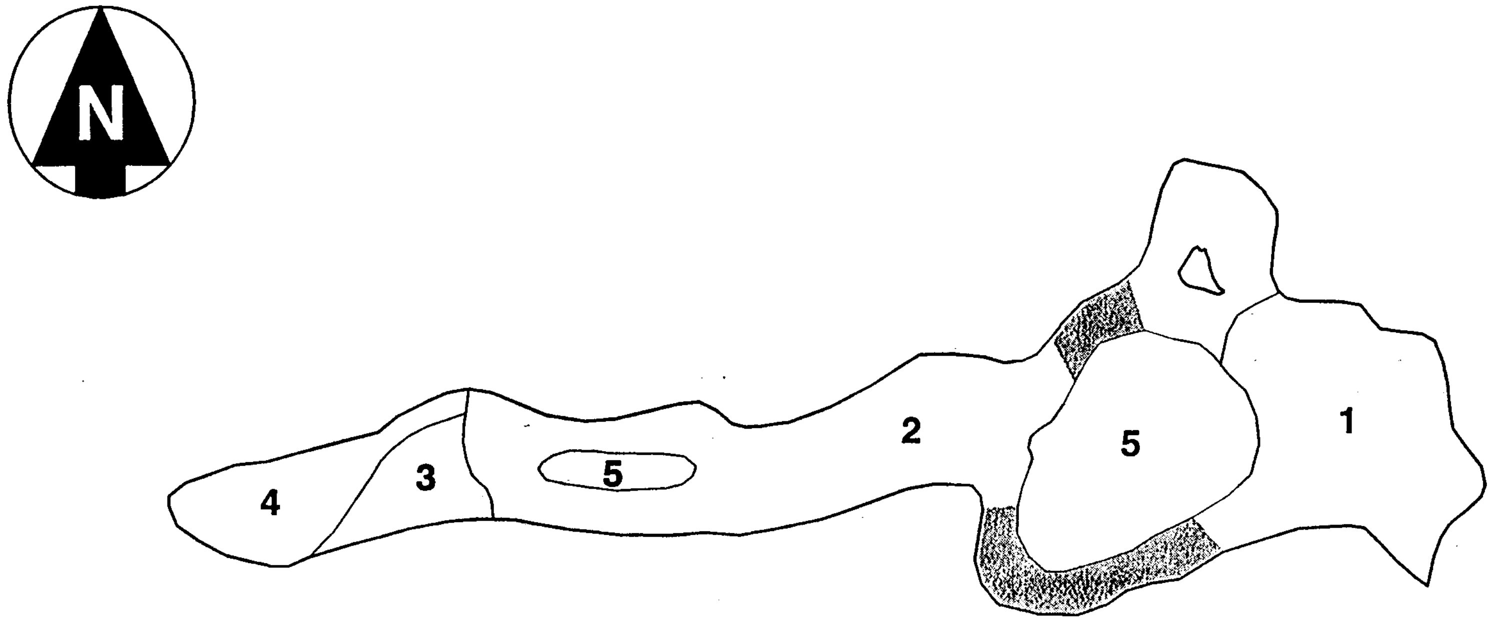
0 100 200 300 400
metres

FIGURE 1.5-14

NWT DIAMONDS PROJECT

Figure 3.1-29
Habitat Zones of Moose Lake
(Site 15)

Source: Rescan



Lake	Total Area (m^2)	Habitat Zone	Substrate Type Boulder (%)	Cobble (%)	Gravel (%)	Fines (%)	Habitat Area (m^2)	Percent Area (%)
Leslie	640,281	1	90	10			185,400	29.0
		2	100				259,600	40.5
		3	60	40			33,500	5.2
		4	20	70		10	56,200	8.8
	Basin	5				100	105,581	16.5
							640,281	100.0

NWT DIAMONDS PROJECT

Figure 3.1-30
Habitat Zones of Leslie Lake
(Site 17)

Source: Rescan

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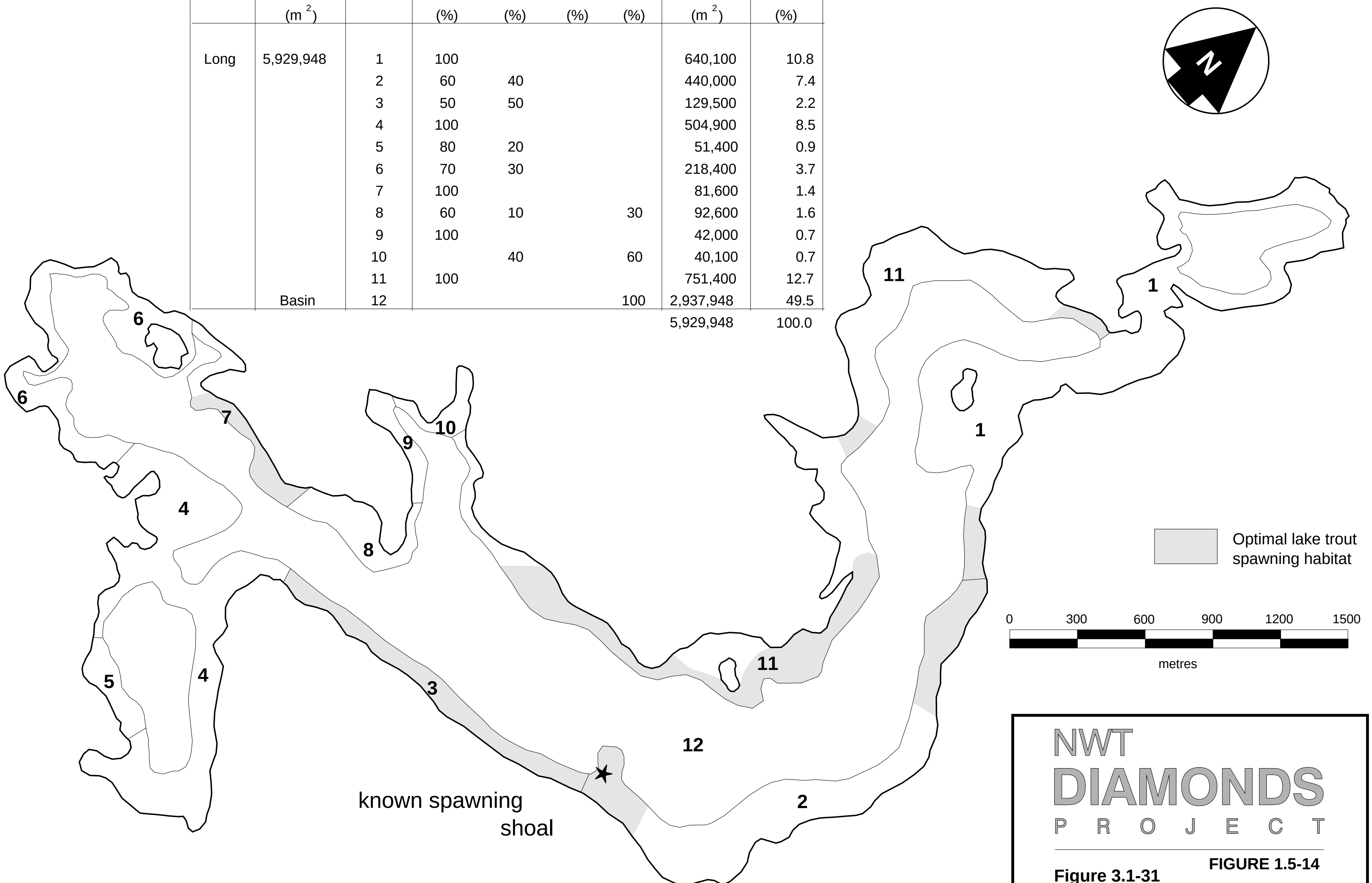
Lake	Total Area (m ^{2})	Habitat Zone	Substrate Type Boulder (%)	Cobble (%)	Gravel (%)	Fines (%)	Habitat Area (m ^{2})	Percent Area (%)
Long	5,929,948	1	100				640,100	10.8
		2	60	40			440,000	7.4
		3	50	50			129,500	2.2
		4	100				504,900	8.5
		5	80	20			51,400	0.9
		6	70	30			218,400	3.7
		7	100				81,600	1.4
		8	60	10		30	92,600	1.6
		9	100				42,000	0.7
		10		40		60	40,100	0.7
		11	100				751,400	12.7
	Basin	12				100	2,937,948	49.5
							5,929,948	100.0



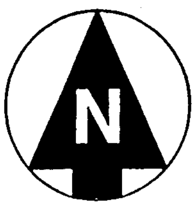
NWT DIAMONDS PROJECT

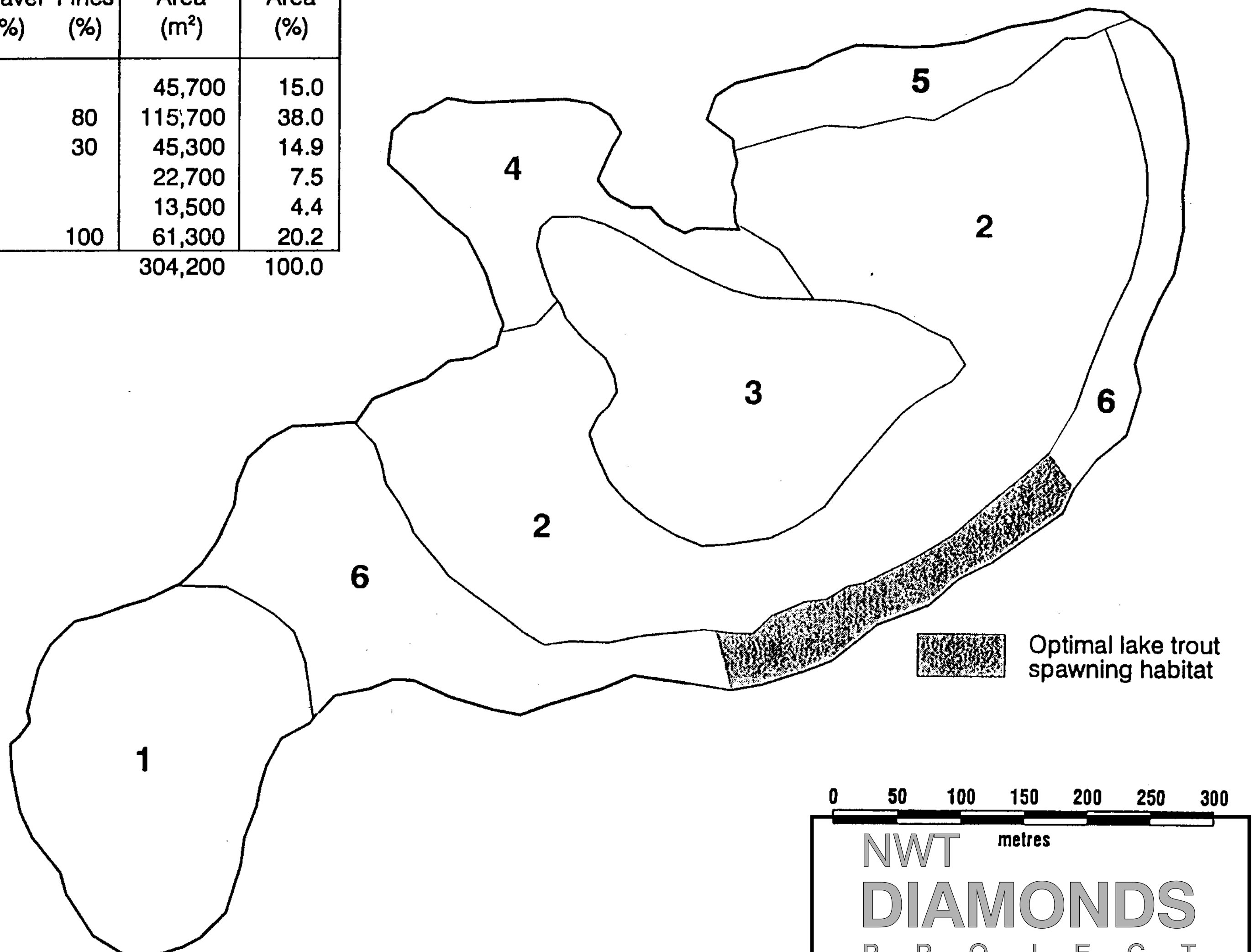
FIGURE 1.5-14

Figure 3.1-31
Habitat Zones of Long Lake (Site 19)

Source: Rescan

Lake	Total Area (m^2)	Habitat Zone	Substrate Type Boulder (%)	Cobble (%)	Gravel (%)	Fines (%)	Habitat Area (m^2)	Percent Area (%)
Little	304,200	1	100				45,700	15.0
		2	20			80	115,700	38.0
		4	50	20		30	45,300	14.9
		5	100				22,700	7.5
		6	80	20			13,500	4.4
	Basin	3				100	61,300	20.2
							304,200	100.0





NWT DIAMONDS PROJECT

Figure 3.1-32
Habitat Zones of Little Lake
(Site 23)

Source: Rescan

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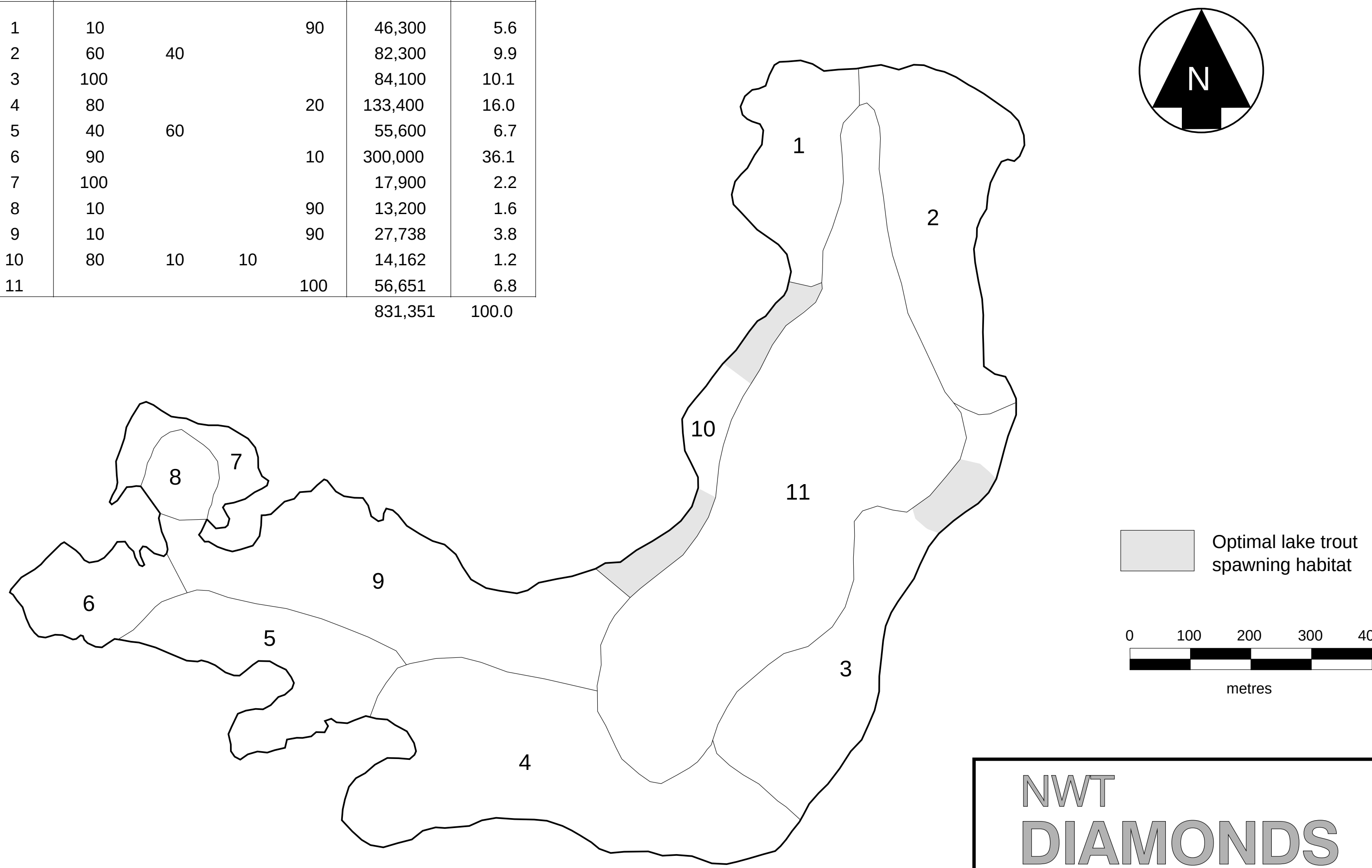
Lake	Total Area (m²)	Habitat Zone	Substrate Type Boulder (%)	Cobble (%)	Gravel (%)	Fines (%)	Habitat Area (m²)	Percent Area (%)
Kodiak	831,351	1	10			90	46,300	5.6
		2	60	40			82,300	9.9
		3	100				84,100	10.1
		4	80			20	133,400	16.0
		5	40	60			55,600	6.7
		6	90			10	300,000	36.1
		7	100				17,900	2.2
		8	10			90	13,200	1.6
		9	10			90	27,738	3.8
		10	80	10	10		14,162	1.2
	Basin	11				100	56,651	6.8
							831,351	100.0



NWT DIAMONDS PROJECT

Figure 3.1-33
Habitat Zones of Kodiak Lake (Site 25)

Source: Rescan

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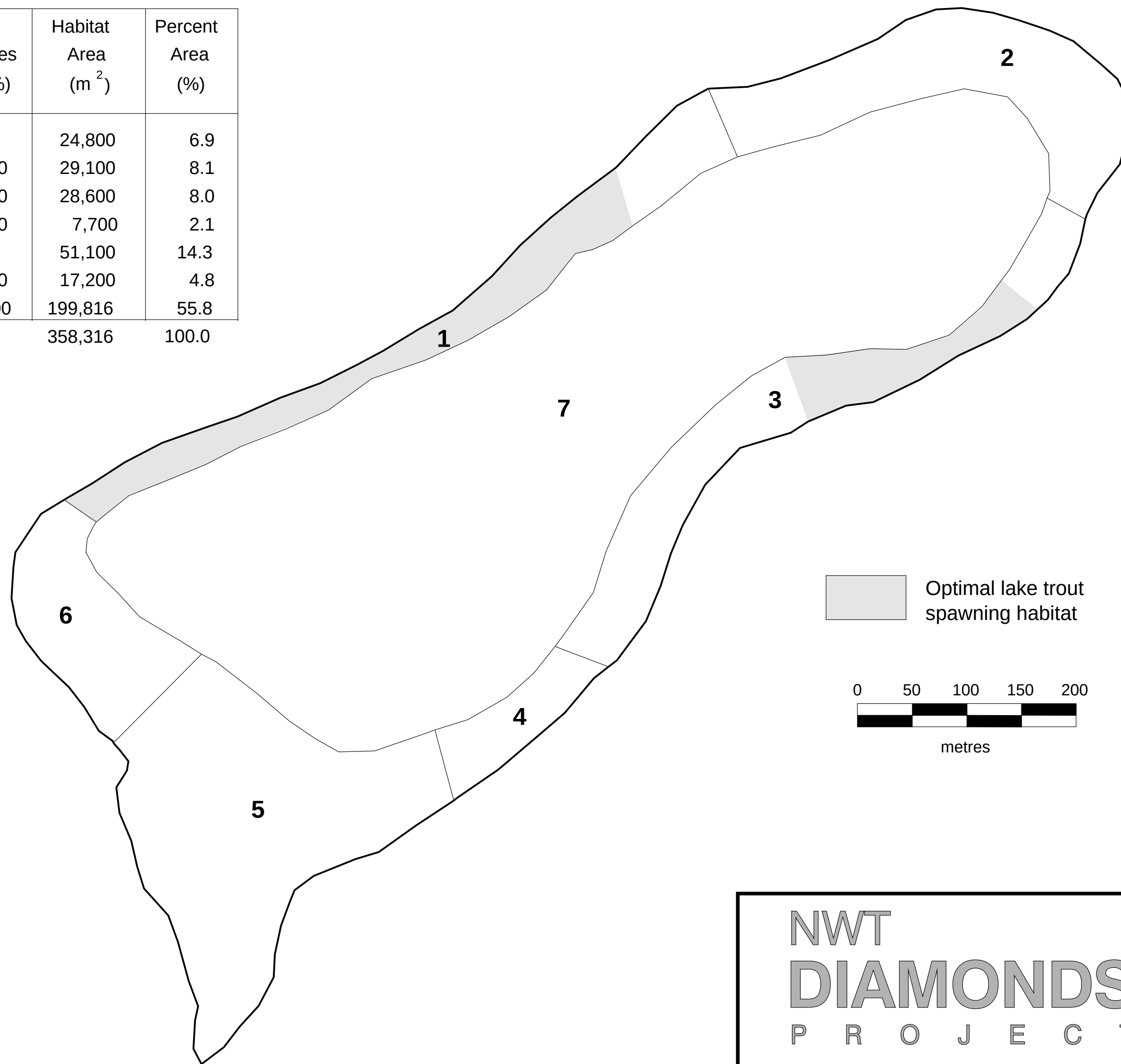
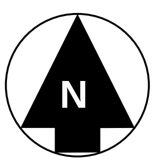
Lake	Total Area (m^2)	Habitat Zone	Substrate Type Boulder (%)	Cobble (%)	Gravel (%)	Fines (%)	Habitat Area (m^2)	Percent Area (%)
Koala	358,316	1	80	20			24,800	6.9
		2	90			10	29,100	8.1
		3	60	20		20	28,600	8.0
		4	60	10		30	7,700	2.1
		5	100				51,100	14.3
		6	10	10		80	17,200	4.8
	Basin	7				100	199,816	55.8
							358,316	100.0





NWT DIAMONDS PROJECT

FIGURE 1.5-14

Figure 3.1-34
Habitat Zones of Koala Lake
(Site 27)

Source: Rescan

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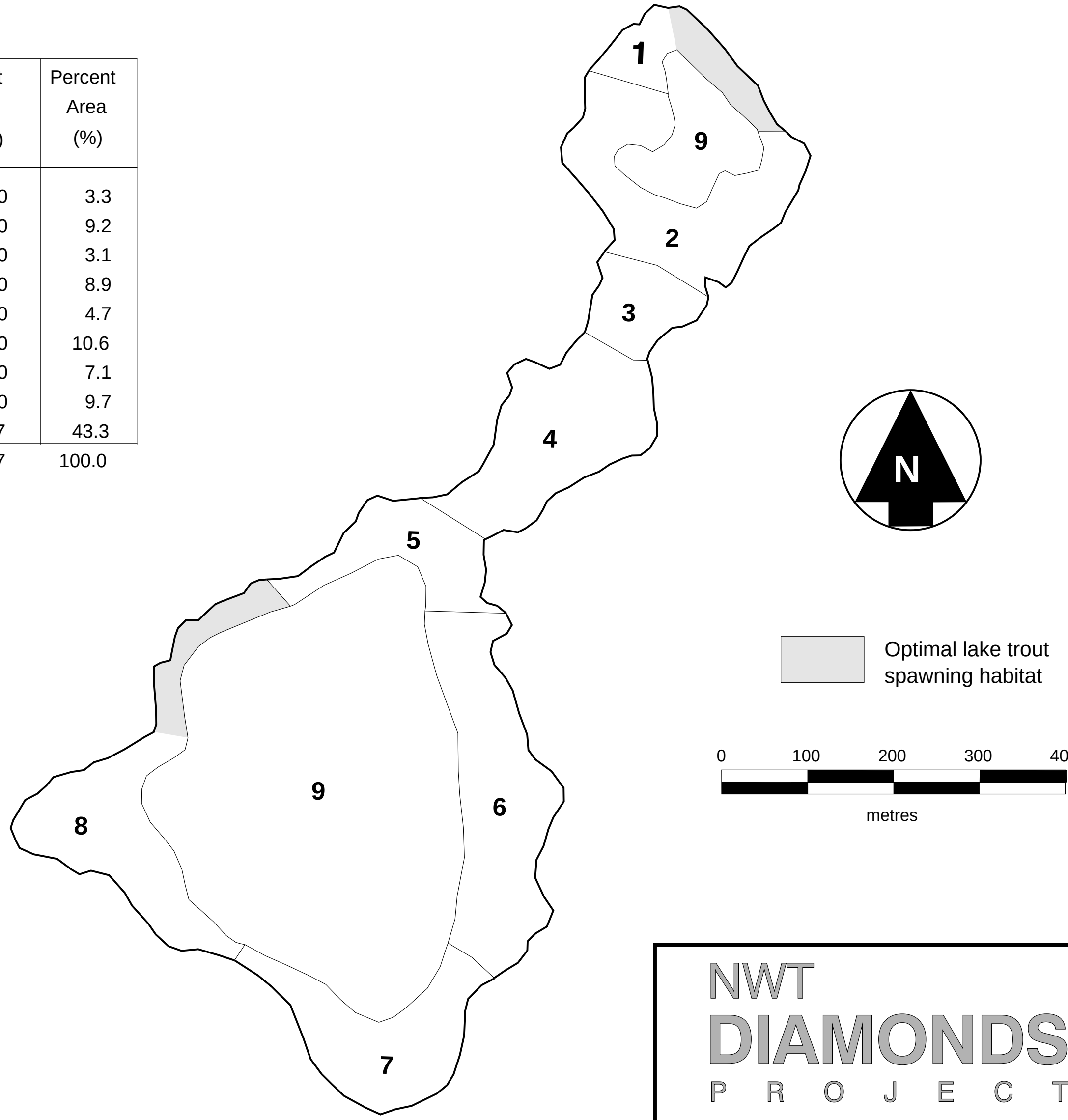
Lake	Total Area (m^2)	Habitat Zone	Substrate Type: Boulder (%)	Cobble (%)	Gravel (%)	Fines (%)	Habitat Area (m^2)	Percent Area (%)
Panda	341,897	1	100				11,400	3.3
		2	80	10		10	31,300	9.2
		3	100				10,500	3.1
		4	10		90		30,500	8.9
		5	10			90	16,000	4.7
		6	80	20			36,300	10.6
		7	50	50			24,400	7.1
		8	100				33,300	9.7
	Basin	9				100	148,197	43.3
							341,897	100.0



NWT DIAMONDS PROJECT

FIGURE 1.5-14

Figure 3.1-35
Habitat Zones of Panda Lake (Site 29)

Source: Rescan

Lake	Habitat Zone	Substrate Type: Boulder (%)	Cobble (%)	Gravel (%)	Fines (%)
1-Hump	1	90	10		
	2				100

NWT DIAMONDS PROJECT

Figure 3.1-36
Habitat Zones of 1-Hump Lake (Site 61)

Source: Rescan

◎ **Table of Contents**

Lake	Total Area (m ^{2})	Habitat Zone	Substrate Type Boulder (%)	Cobble (%)	Gravel (%)	Fines (%)	Habitat Area (m ^{2})	Percent Area (%)
Nema	775,041	1	80	20			8,000	1.0
		2	100				183,000	23.6
		3	90	10			16,000	2.1
		4	100				14,000	1.8
		5	70	10		20	131,000	16.9
		6	60	40			87,000	11.2
		7	90	10			28,000	3.6
		8	70	20		10	131,700	17.0
	Basin	9				100	176,341	22.8
							775,041	100.0

NWT DIAMONDS PROJECT

Figure 3.1-37
Habitat Zones of Nema Lake
(Site 62)

Source: Rescan

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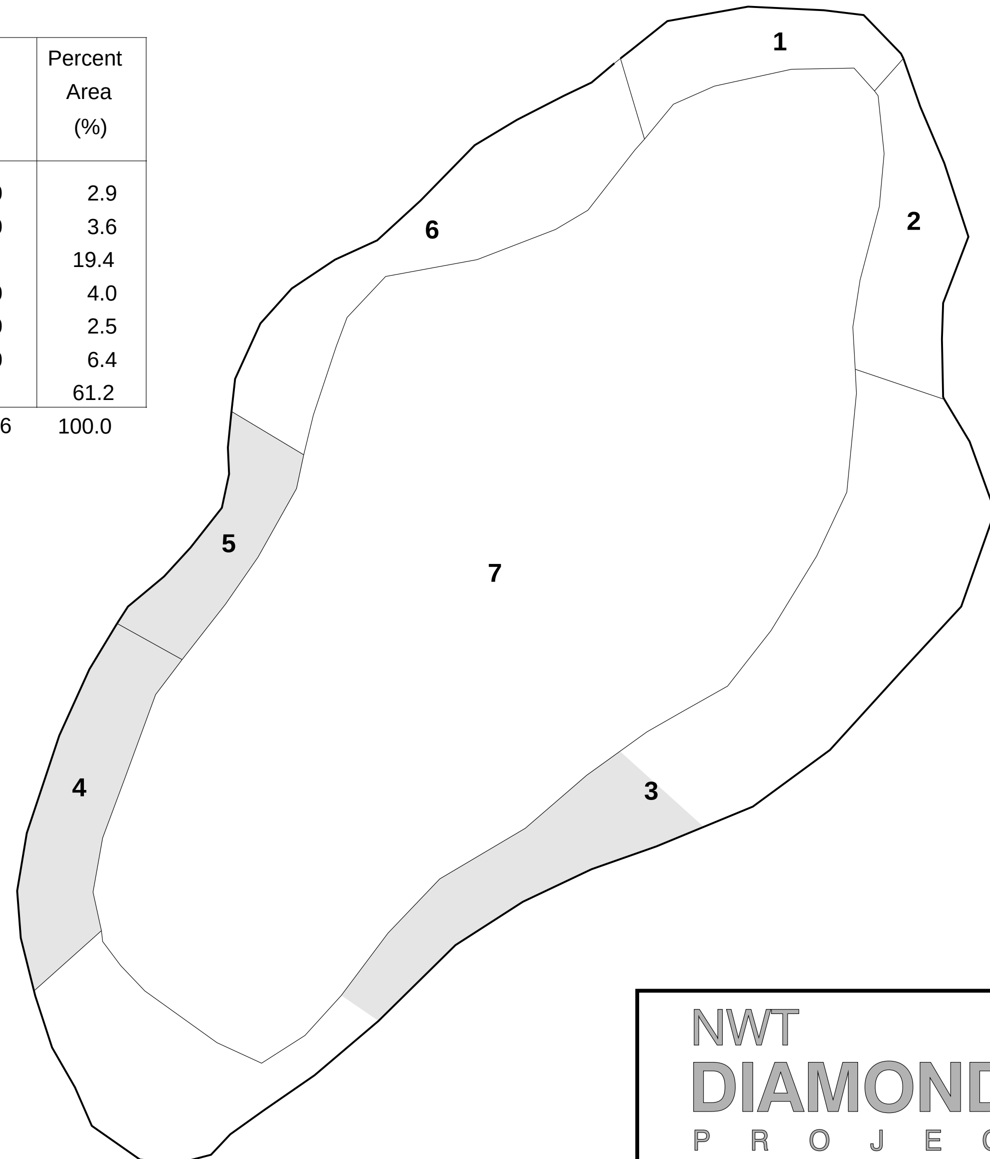
Lake	Total Area (m²)	Habitat Zone	Substrate Type Boulder (%)	Cobble (%)	Gravel (%)	Fines (%)	Habitat Area (m²)	Percent Area (%)
Misery	135,766	1	90	10			3,900	2.9
		2	70	30			4,900	3.6
		3	100				26,400	19.4
		4	70	30			5,400	4.0
		5	60	30	10		3,400	2.5
		6	80	10	10		8,700	6.4
	Basin	7				100	83,066	61.2
							135,766	100.0



N

Optimal lake trout spawning habitat

0 30 60 90 120 150
metres

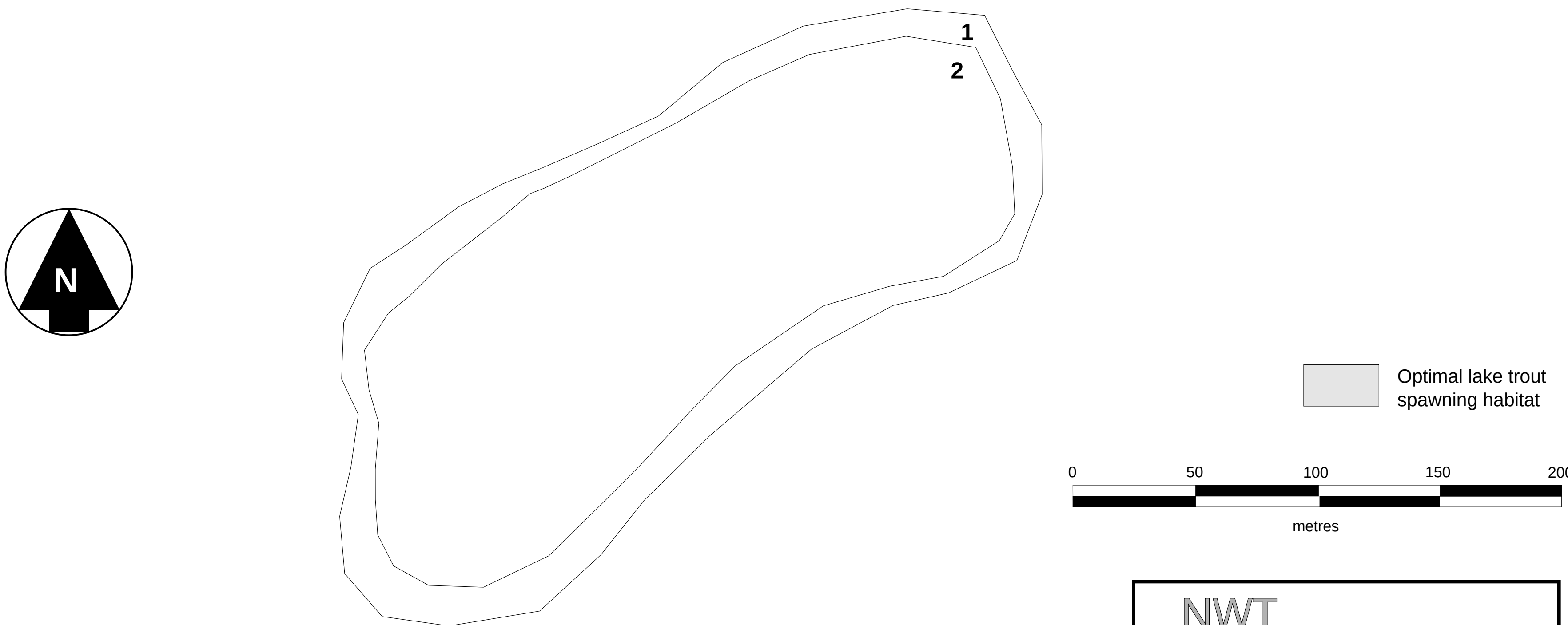
NWT DIAMONDS PROJECT

Figure 3.1-38
Habitat Zones of Misery Lake (Site 48)

Source: Rescan

◎ Table of Contents

Lake	Total Area $(m)^2$	Habitat Zone	Substrate Type: Boulder (%)	Substrate Type: Cobble (%)	Substrate Type: Gravel (%)	Substrate Type: Fines (%)	Habitat Area $(m)^2$	Percent Area $(m)^2$
Arnie	76,299	1	80	10		10	42,007	55%
		2	10	10		80	34,292	45%
							76,299	100%



NWT DIAMONDS PROJECT

Figure 3.1-39
Habitat Zones of Arnie Lake
(Site 44)

Source: Rescan

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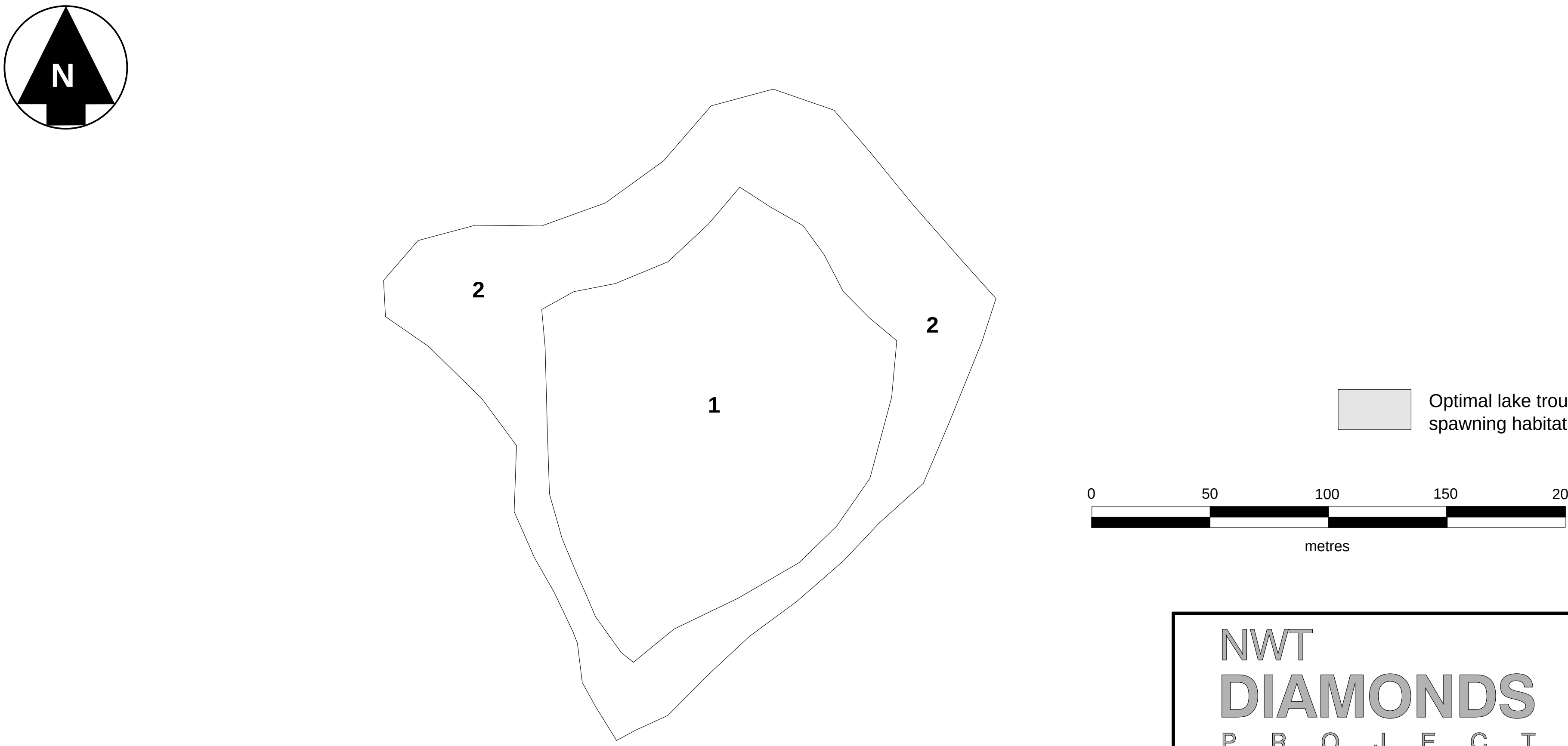
Lake	Total Area (m²)	Habitat Zone	Substrate Type Boulder (%)	Cobble (%)	Gravel (%)	Fines (%)	Habitat Area (m²)	Percent Area (%)
Mark	46,300	1	50	30		20	23,300	50.3
	Basin	2				100	23,000	49.7
							46,300	100.0



NWT DIAMONDS PROJECT

Figure 3.1-40
Habitat Zones of Mark Lake
(Site 46)

Source: Rescan

Study lakes with sufficient depth were found to have areas of optimal lake trout spawning habitat (Figures 3.1-26 to 3.1-38). Future efforts to identify spawning areas can be concentrated in these mapped areas. In addition, optimal habitat criteria can be adjusted according to actual known sites.

Two spawning sites identified in 1994 had similar habitat compositions to the criteria mentioned. One spawning site was found in Fox 1 Lake (Figure 3.1-27) and one in Long Lake (Figure 3.1-31). The Fox 1 site was a shallow (1.5 m) cobble shoal. The Long Lake spawning site was off a rock island on a clean cobble and boulder reef. Spawning sites do not appear to be limiting lake trout reproduction in any of the study lakes where they are currently established.

Spawning sites were not determined for other lake spawning species. Round whitefish are fall spawners like lake trout, but they often spawn under the ice in northern lakes and therefore were not observed before the end of the 1994 field season. Burbot spawn under ice in late winter and, similarly, spawning behaviour could not be determined from visual observations (McPhail and Lindsey 1973; Scott and Crossman 1970).

3.1.3.4 Species Distribution

Seven fish species were caught in the study area in 1993 and 1994. These species included lake trout (*Salvelinus namaycush*), round whitefish (*Prosopium cylindraceum*), arctic grayling (*Thymallus arcticus*), burbot (*Lota lota*), longnose sucker (*Catostomus catostomus*), slimy sculpin (*Cottus cognatus*) and lake chub (*Couesius plumbeus*). The species compositions of the study lakes are characteristic of the region, although lake whitefish (*Coregonus clupeaformis*) and cisco (*Coregonus artedii*) are often present in similar lakes. The distribution of fish species found in the study streams and lakes is shown in Tables 3.1-20(a) and (b), respectively.

During spring freshet, streams were occupied primarily by adult arctic grayling. Longnose suckers, which frequently spawn in streams during the freshet, were not observed in streams during 1994. During the summer, stream water levels were generally too low to support mature fish, although streams with some surface flow were occupied primarily by juvenile arctic grayling, as well as slimy sculpin and juvenile burbot. Declining flows in the fall probably trigger migration of fish to lakes to over winter.

The dominant species inhabiting the area lakes were lake trout, round whitefish and arctic grayling, while burbot and longnose sucker were infrequent. Small fish species present in lakes include slimy sculpin and lake chub; however, lake chub was reported in 1-Hump Lake only.

Table 3.1-20 (a) and (b)
Distribution of Fish Species Within the
NWT Diamonds Project Site, 1994

a) Streams

Stream	Site #	Lake Trout	Round Whitefish	Arctic Grayling	Burbot	Longnose Sucker	Slimy Sculpin
Vulture-Polar	31			X			X
Grizzly-Panda	30						
Nancy-Long	21						
Long-Leslie	18	X		X	X		X
Leslie-Moose	16						
Panda-Koala	28	X	X	X	X		X
Koala-Kodiak	26			X			X
Kodiak-Little	24			X	X		X
Little-Moose	22			X	X		
Larry-Nero	11					X	
Airstrip-Larry	13						
Fox 1-Fox 2	6						
Slipper-Lac de Gras	33			X	X		X
Ursula	36			X			X
South	42						

b) Lakes

Lake	Site #	Lake Trout	Round Whitefish	Arctic Grayling	Burbot	Longnose Sucker	Slimy Sculpin[1]	Lake Chub
Long	19	X	X	X	X		X	
Leslie	17	X	X	X	X			
Panda	29	X	X	X	X		X	
Koala	27	X	X	X	X		X	
Kodiak	25	X	X	X				
Little	23	X	X	X			X	
Moose	21	X	X	X		X		
Nema	62	X	X			X		
Fox 3	5	X	X	X		X[2]		
Mike	2	X	X	X		X	X	
1 Hump	61	X	X	X		X		X
Fox 1	6	X			X			
Misery	48	X						
Larry	12	X			X[3]		X	
Mark	46			X				
Buster	60			X				

1: Slimy sculpin were more commonly found in lake trout stomachs, than by direct capture and are assumed to be very widespread in the local area.
2: Longnose sucker were captured in 1993 field season, but not in 1994.
3: One burbot was sighted.

Fish populations in study area lakes formed three general community types: 1) arctic grayling as the sole species; 2) lake trout as the sole species (with minor occurrence of burbot); and 3) lake trout and round whitefish as the dominant species, with grayling, burbot and longnose sucker occurring as minor species. Slimy sculpin were found in most lakes, and are assumed to be widespread.

Single-species arctic grayling communities were found in Mark and Buster lakes, which are small (<5 ha) and are relatively shallow (<7 m). Small lakes may provide poor habitats for species such as lake trout, round whitefish, and burbot due to the following factors: 1) limited habitat area, especially in the winter during periods of maximum ice cover; 2) high summer temperatures for species that prefer cooler water; and 3) streamflow entering and exiting these small lakes only during the freshet.

Single-species lake trout communities were found in Fox 1, Misery, and Larry lakes. Fox 1 and Misery lakes are located in headwater positions and Larry Lake is isolated from adjoining lakes by subsurface streams flows beneath large boulder complexes and dense shrub vegetation. This occurrence may suggest that lake trout were the first to invade these lakes after glacial retreat.

Multiple-species communities, in which lake trout and round whitefish dominate, were the most common community type. These included Panda, Koala, Kodiak, Nema, Moose, Leslie, Long, Mike, Fox 3 and 1-Hump lakes.

A relationship between the abundance of the various species and the physical characteristics of the lakes was observed. Grayling can evidently survive in the smallest and shallowest lakes, and lake trout dominate the largest and deepest lakes. The most likely explanation for dominance of lake trout is that they prey heavily on other species in the deepest and least productive lakes. Thus, the lakes with outlying characteristics show relatively distinct patterns while the lakes with intermediate characteristics show no discernible patterns with respect to the species present.

Similar species compositions to those of the Koala drainage were found in lakes in the upper Coppermine drainage (the Izok Mine project area, located about 250 km south of Coronation Gulf and 90 km west of Echo Bay's Lupin Mine). In the Izok Mine project area, lake trout, round whitefish and longnose suckers were present in high relative abundance, compared to arctic grayling, burbot and lake cisco. Lake cisco were not found in the Koala drainage and lake chub were not encountered in the Izok Mine project area. Streams within the Izok Mine project area contained arctic grayling, lake trout, burbot and slimy sculpin. Lake whitefish, which were reported to occur in the Izok Mine area in 1977, were not encountered in latter surveys (1992-1993). It was suggested that round whitefish may have been misidentified as lake whitefish (Ash 1994).

The species composition of the Koala drainage was also similar to the Contwoyto Lake area, about 100 km north of the study lakes and adjacent to the Coppermine drainage. In streams, arctic grayling predominated, with small numbers of ninespine stickleback (*Pungitius pungitius*), lake trout, round whitefish, lake cisco, and burbot. The fish species found in Contwoyto Lake include lake trout, arctic char (*Salvelinus alpinus*), arctic grayling, round whitefish, burbot, lake cisco, ninespine stickleback and slimy sculpin. Of these, arctic char and ninespine stickleback were not found in the NWT Diamonds project study lakes. Conversely, of the species found in study lakes, lake chub (*Couesius plumbeus*) was not found in Contwoyto Lake.

3.1.3.5 Catch per Unit Effort and Relative Abundance

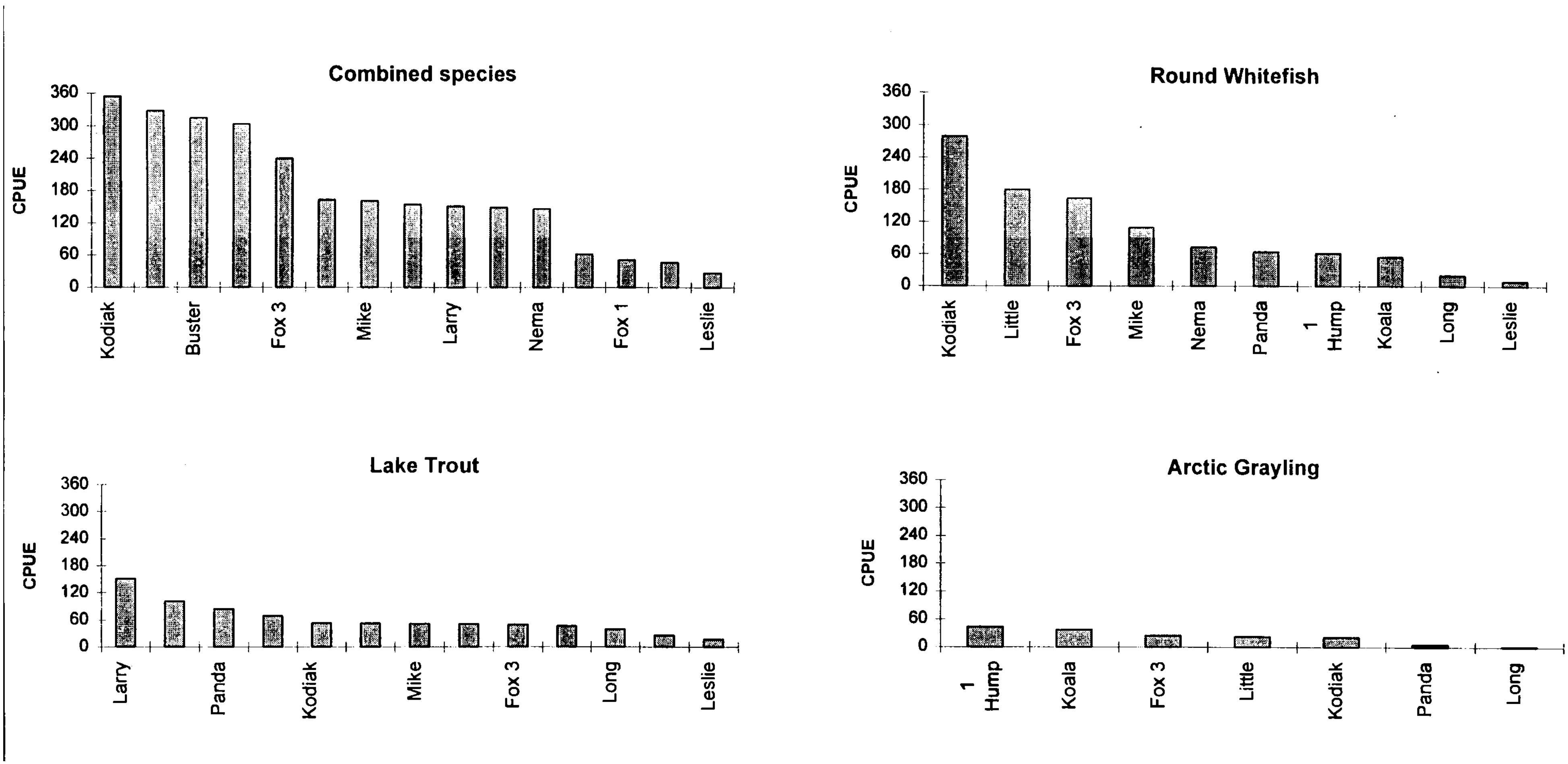
Catch per unit effort (CPUE) is defined as the number of fish caught per standard unit of fishing gear and/or per unit of time (Ryder *et al.* 1974). Aboriginal people frequently employ this concept when fishing at lakes. Often when energy expenditures are not producing the anticipated returns, instead of fishing lakes “out”, nets are lifted and set at another location. The lake is then not fished again for several years, allowing fish stocks to recover (Freeman and Stevenson 1995). Thus, CPUE is frequently employed by Aboriginal people as a successful management tool.

The relative abundance, i.e., the percent composition of fish species within a catch, was calculated for each study lake using the CPUE. Detailed catch statistics and the CPUE and relative abundance (percent) calculations are contained in Appendix II-B9.

Catch per Unit Effort

Three distinct groupings of index gillnetting CPUE values were evident: 1) low CPUE values (27 fish/100 m/24 h to 62 fish/100 m/24 h) were obtained in Leslie, Misery, Fox 1 and Long lakes; 2) moderate values (146 fish/100 m/24 h to 163 fish/100 m/24 h) were obtained in Nema, 1-Hump, Larry, Panda, Mike and Koala lakes; and 3) high values (230 fish/100 m/24 h to 354 fish/100 m/24 h) were obtained in Fox 3, Little, Buster, Mark and Kodiak lakes.

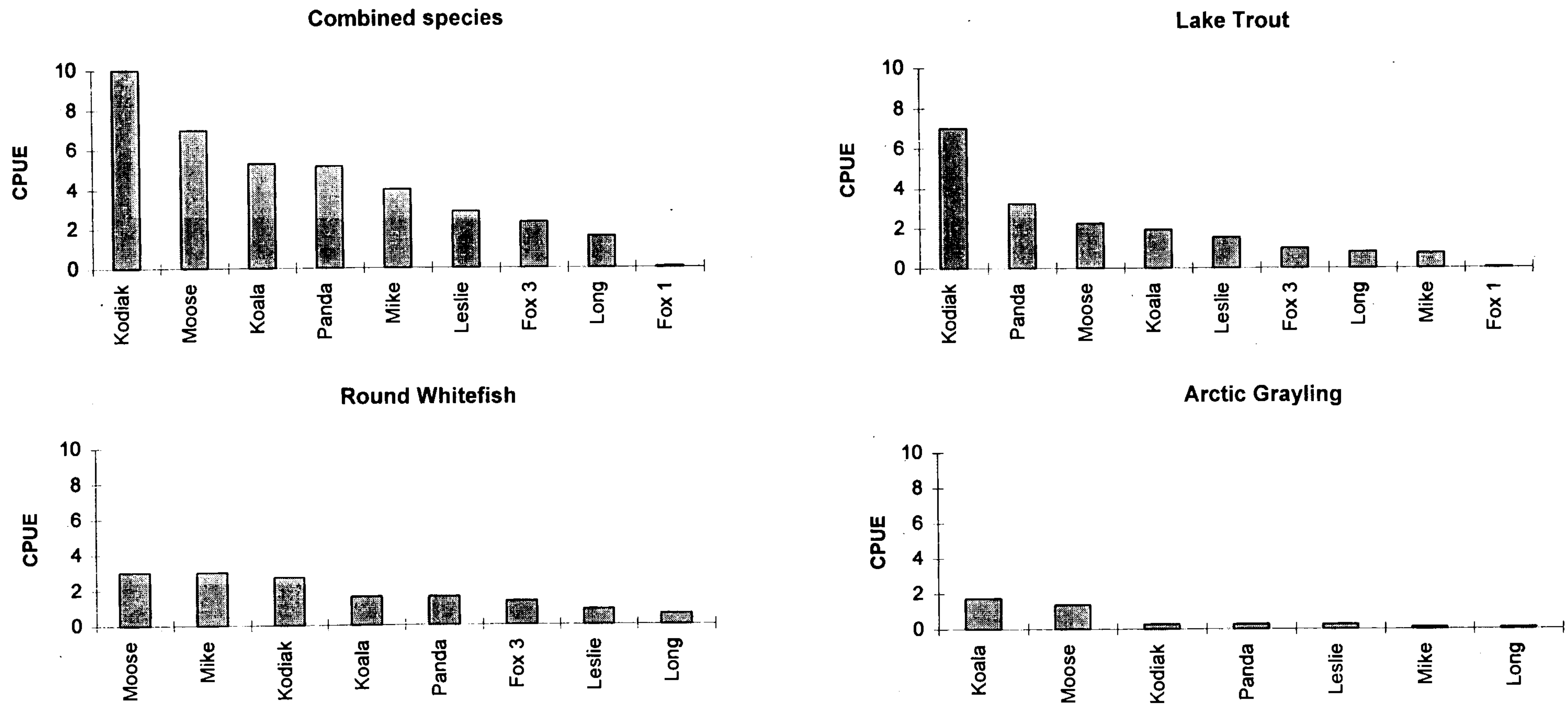
Low CPUE values appear to be associated with deep lakes and a high proportion of lake trout. Moderate CPUE values are generally associated with lakes exhibiting a wide range of morphometry and relatively balanced numbers of lake trout and round whitefish. High CPUE values appear associated with small, shallow lakes (Appendix II-B9). The CPUE was extremely variable for round whitefish and arctic grayling (Figures 3.1-41 and 3.1-42). The CPUE for burbot and longnose sucker was low due to their low abundance.



NWT DIAMONDS PROJECT

Figure 3.1-41
Catch per Unit Effort
by Index Gillnetting

Source: Rescan



NWT DIAMONDS PROJECT

Figure 3.1-42
Catch per Unit Effort
by Index Trapnetting

Source: Rescan

Index gillnetting CPUE for lake trout was low for Leslie Lake and high for Larry and Little lakes. Intermediate CPUE values for the remaining nine lakes were similar. Trapnetting CPUE values were low in Fox 1 and Long lakes while Panda, Koala and Kodiak lakes were high.

Index gillnetting CPUE for round whitefish was relatively low for Leslie and Long lakes, but was high for Kodiak, Little and Fox 3 lakes. Intermediate CPUE values were obtained for round whitefish from Nema, Panda and Koala lakes. Trapnetting CPUE showed similar patterns.

Index gillnetting CPUE for arctic grayling was highest in Mark and Buster lakes (<5 ha), which both exclusively contain arctic grayling. In lakes where arctic grayling were present with other species, CPUE for Koala Lake ranked highest.

The CPUE for grayling was very low for Long and Panda lakes. Trapnetting CPUE for grayling was high in Koala and Moose lakes and very low in the remaining lakes.

The absence of some species in a catch does not mean that they are not present, as some species are captured by one method and not another.

Relative Abundance

Relative abundance was determined from CPUE estimates from index gillnetting and trapnetting data and is summarized in Table 3.1-21 (source data in Appendix II-B9). These fish capture methods often yielded different percent abundance values as each method is more selective towards different species and size ranges.

Lake trout and round whitefish were found in high relative abundance and accounted for at least 75% of the total number caught when they occurred together. Single species lake trout populations (>90% occurrence) were found in Fox 1, Misery, and Larry lakes. Longnose suckers, burbot and lake chub were found in low relative abundance. Arctic grayling were generally found in low relative abundance, except in Koala, Kodiak, Little and Moose lakes (all directly connected).

3.1.3.6 Population Estimates

Fish population estimates were obtained for six mark-recapture lakes designated for either open pit mining or tailings disposal. During the ice-free period, a total of 657 fish (>300 mm fork length) were tagged with numbered Floy tags including 502 lake trout, 80 round whitefish, 63 arctic grayling and 12 burbot. Sampling periods lasted approximately one week and at least ten days lapsed between samplings. Any fish recaptured in the same period was not considered as a recapture in the population estimate.

Table 3.1-21
Relative Abundance (%) of Fish Species Captured by Index Gillnets (15 lakes) and Trapnets (nine lakes)

a) Index Gillnetting

Site	Lake Trout	Round Whitefish	Arctic Grayling	Burbot	Longnose Sucker
Fox 1	100				
Misery	100				
Larry	100				
Leslie	67	33			
Long	65	32	3		
Panda	55	41	4		
Koala	43	33	23	1	
Nema	36	49			14
Little	33	59	7		
Mike	32	68			
Fox 3	21	68	11		
1 Hump	18	41	29		12
Kodiak	15	79	6		
Mark			100		
Buster			100		

b) Trapnetting

Site	Lake Trout	Round Whitefish	Arctic Grayling	Burbot	Longnose Sucker
Fox 1	100				
Kodiak	70	27	3		
Panda	63	31	5	1	
Leslie	53	30	9	7	
Long	51	38	6	6	
Fox 3	43	57			
Koala	36	30	33	1	
Moose	32	43	20		5
Mike	19	75	3		3

Population estimates, using Petersen's method (revised by Chapman), were attempted only for species with at least four recaptured fish, as recommended by Ricker (1975). Lake trout was the only species with a sufficient number of recaptures to obtain population estimates. Estimates could be calculated for three of six lakes: Panda, Koala and Misery (Table 3.1-22; Appendix II-B10).

Panda and Koala lakes were sampled over at least three sampling periods. A sufficient number of recaptured fish were obtained to provide more than one population estimate for the same lake. Two population estimates were obtained for Panda Lake with 259 lake trout in the first estimate, and 234 in the second estimate. Two population estimates (90 and 126 lake trout) were also obtained for Koala Lake. Only one sampling period was used to obtain a population estimate of 91 fish for Misery Lake.

As 300 mm is the lower size limit, these estimates represent the adult fish population and the portion of the population approaching reproductive maturity. These estimates also represent the portion of the population most vulnerable to angling, as fish smaller than 300 mm are expected to be released.

The validity of population estimates using the Petersen method is based on several assumptions, and any deviation from these assumptions will bias the estimate. Ricker (1975) highlights six important assumptions that must be met to produce a reliable population estimate which should be addressed if these conditions are not met. These assumptions are addressed in Appendix II-B10. Some biases were evident but are expected to minimally affect the estimates.

An important assumption in Petersen's method is that the system is a closed population (no immigration or emigration). Immigration and emigration were observed in arctic grayling populations. Five arctic grayling were recaptured in Koala Lake. One of these recaptures was originally tagged in the mid-reach of Koala-Kodiak stream during spawning season (June) and later recaptured in Koala Lake near the outflow of Panda-Koala stream. Another grayling originally tagged in Koala Lake in June was later recaptured in August in the northeast basin of Panda Lake. Since Petersen's method depends on the system being closed, estimates were not obtained for arctic grayling. No lake trout were found in lakes other than where they had been originally tagged.

3.1.3.7 Age Estimates

Fish aging was verified by comparing different aging tissues collected from the same fish. For each type of aging tissue, mean age was calculated from each aging tissue for every 50 mm fork length class. The difference between the two mean ages shows the effect of fish size on the comparability of different aging tissues taken from the same fish. This comparison addresses the general

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Table 3.1-22
Population Size Estimates for Lake Trout (> 30 cm) in Panda, Koala and Misery Lakes (1994)

Lake	1st Period	# Marked (Mt)	2nd Period	# Caught (Ct)	# Recaps (Rt)	Rt C.L. Lower	Rt C.L. Upper	Population Size* (N)	N C.L. Lower	N C.L. Upper	Variance V(N)
Panda	06/14 to 07/01	71	08/11 to 09/05	71	19	12.2	30.8	259	163	393	2311
Panda	06/14 to 08/16	91	09/01 to 09/05	32	12	6.2	21	234	138	422	2361
Koala	06/07 to 06/22	11	07/13 to 09/17	59	7	2.8	14.4	90	47	189	780
Koala	06/07 to 07/27	15	08/06 to 09/17	54	6	2.2	13.1	126	62	275	1724
Misery	08/07 to 08/09	15	09/04 to 09/18	33	5	1.6	11.7	91	43	209	967

* Petersen population estimate (modified by Chapman) based on single recaptures from Ricker (1975).
C.L. = 95% confidence limits from Ricker 1975.
Population size (N) = (Ct+1)*(Mt+1)/(Rt+1) (Ricker 1975).
Sample variance (V(N)) = [N^2*(Ct-Rt)]/[(Ct+1)*(Rt+2)].

assumption that large, slow growing individuals fail to produce discernible annuli on scales and fin rays, while otoliths continue to produce discernible annuli.

Lake Trout

Age data for lake trout populations were pooled to represent two community types (Maclean *et al.* 1990). The first community type represents multiple species communities, including lake trout, round whitefish and arctic grayling, while the second represents lake trout as a single species. In the first community type, fin ray age was generally about two years less than otolith age for all fish below 600 mm (Table 3.1-23a, b). The difference increased to about three years for fish larger than 600 mm; however, this group was represented by only three lake trout. In the second community type, the difference was slightly less, averaging about 1.6 years between mean fin ray age and otolith age.

These results indicate that fin rays provide reliable estimates of age for lake trout, assuming that otolith ages closely represent the true age. For fin rays collected in 1995, a correction factor of +2 years will provide age estimates comparable to ages obtained by otoliths and a reasonable approximation of the true age structure of a population.

Round Whitefish

Mean otolith age was consistently greater than mean scale age regardless of size (Table 3.1-23c). The difference between scale and otolith age was variable, ranging from 2.3 to 3 years for fish <350 mm, and between 3.3 and 4.5 years for fish larger than 350 mm. On average, mean scale age was 3.2 years less than mean otolith age. Fin ray tissues will be collected in 1995 to determine if they provide a more reasonable age estimate.

Although otoliths produce the most reliable estimate of true age, there may be limitations to its accuracy. Annuli formations in the otoliths of old lake whitefish are known to develop differently if viewed in cross section or laterally (Power 1978). For lake whitefish older than about 15 years, otoliths cease to grow around the lateral edges and grow mainly in thickness, thus annuli can be seen only in cross-section. Therefore, otoliths cut laterally will show a lower age than if the otolith is viewed in cross-section. This pattern has not been documented for round whitefish; however, it is likely to be similar because round whitefish can live as long as lake whitefish. Since round whitefish otoliths were viewed laterally only, fish older than 15 otolith years, may likely be much older. Individuals older than 15 otolith years will be excluded from growth analysis, as mean length at age is overestimated if age is underestimated.

Table 3.1-23
Age Verification for Different Aging Tissues for Lake Trout, Round Whitefish and Arctic Grayling

a) Lake Trout – Multiple Species Community*

Length Class (mm)	Sample Size (n)	Mean Length (mm)	Mean Age Fin Ray (yrs)	Otolith (oto) (yrs)	Difference (fin ray - oto) (yrs)
100 to 200	8	185	4.4	6.3	-1.9
201 to 300	58	243	5.8	8.0	-2.2
301 to 400	32	344	8.8	10.4	-1.6
401 to 500	22	451	12.3	14.0	-1.7
501 to 600	5	554	14.2	15.8	-1.6
>600	3	670	18.0	20.7	-2.7
Total	128				
Weighted Mean		323	8.2	10.1	-1.9

* Combined data from Long, Leslie, Panda, Koala, Little, Mike, Nema, Fox 3 lakes.

b) Lake Trout – Single Species Community*

150 to 200	5	185	4.4	5.6	-1.2
201 to 300	28	249	5.9	7.7	-1.8
301 to 400	46	353	10.0	11.5	-1.5
>400	6	408	11.8	14.0	-2.2
Total	85				
Weighted Mean		312	8.5	10.1	-1.6

* Combined data for Fox 1, Misery and Larry lakes.

(continued)

Table 3.1-23 (completed)
Age Verification for Different Aging Tissues for Lake Trout, Round Whitefish and Arctic Grayling

c) Round Whitefish*

Length Class (mm)	Sample Size (n)	Mean Length (mm)	Mean Age Fin Ray (yrs)	Otolith (oto) (yrs)	Difference (fin ray - oto) (yrs)
150 to 200	2	189	4.5	7.0	-2.5
201 to 250	3	243	4.7	7.7	-3.0
251 to 300	31	280	5.6	8.1	-2.5
301 to 350	39	332	6.8	9.1	-2.3
351 to 400	84	378	8.5	12.0	-3.5
401 to 450	35	413	9.2	13.7	-4.5
451 to 500	3	467	10.7	14.0	-3.3
Total	197				
Weighted Mean		348	7.5	10.8	-3.3

* Combined data from Long, Leslie, Panda, Koala, Little, Mike, Nema and Fox 3 lakes.

d) Arctic Grayling*

<200	2	183	3.5	5	-1.5
201 to 300	11	243	4.3	5.6	-1.3
301 to 400	6	365	6.5	9.8	-3.3
Total	19				
Weighted Mean		275	4.9	6.9	-2.0

* Combined data from Long, Leslie, Panda, Koala and Mike lakes.

Arctic Grayling

Because of the small sample size of otolith tissues, the differences between aging tissues collected from the same fish could not be accurately described. From the available data, however, scales yielded lower age estimates than otoliths (Table 3.1-23d). The difference was about 1.5 years for fish smaller than 300 mm and 3.3 years for fish larger than 300 mm. A smaller subsample of fin rays was available for comparison to otolith age, and age estimates were much more comparable. For future grayling aging, fin rays will be collected exclusively and an estimate of bias will then be quantified.

3.1.3.8 Age Distribution

In describing age distributions from a sample of the total population, biases are usually inherent because most conventional types of sampling equipment are selective towards particular size groups and consequently towards particular age groups. Therefore, age distributions are described for each method, and populations between lakes are compared for similar capture methods.

Lake Trout

Considerable variation existed in the age distribution between different sampling methods (Table 3.1-24). Night gillnetting yielded a higher proportion of juvenile lake trout, while trapnetting yielded a higher proportion of adult lake trout. During night gillnetting, juvenile lake trout become more active, whereas for trapnetting, juvenile fish can escape through the mesh. Subsequently, mean age was generally youngest for night gillnetting catches, ranging from seven to nine fin ray years, and oldest for trapnetting catches, ranging from 12 to 14 fin ray years. Mean age of day gillnetting catches varied considerably between populations, ranging from seven to 13 fin ray years.

Round Whitefish

While age distributions between populations showed some variation, a variation was greater between aging tissues (Table 3.1-25). For scale age distribution, fish were highly clustered between six and nine years of age, while otoliths showed a wider distribution of older fish, ranging from seven years to 13 years of age.

Otolith ages were found to represent the size distribution of the total catch in six lakes (Panda, Koala, Fox 3, Kodiak, Mike and Nema). Mean otolith age for whitefish from these lakes was highest for trapnetting (13.6 years), intermediate for day gillnetting (10.7 years) and lowest for night gillnetting (10.3 years; Appendix II-B11).

Table 3.1-24
Age Distribution for Lake Trout by
a) Day Gillnetting, b) Night Gillnetting and c) Trapnetting

a) Day Gillnetting

Age (yrs)	Long	Leslie	Panda	Koala	Fox 1	Misery	Kodiak	Larry	Nema	Fox 3	Mike	Moose	Age (yrs)
3				1									3
4	1		2	1	1								4
5				2	1	5				1	2		5
6	3	2	1	7	3	3			1	1	1		6
7	1	1		2	7	2			4	2	4		7
8	3		5	1	5	2	1		1	2	1		8
9	2		5		8	3			1		4		9
10	2	5	6	3	9	6	1		2		3		10
11	7	4	5		5	5			1	2	3		11
12	7	2	3		1	8	2						12
13	5		3		5	4	3		3		2		13
14	3	3		2		7			3		1		14
15	4	1			1	6	2		4		1		15
16	2	1	1				1		2				16
17									1				17
18						1							18
19	1								1		1		19
20	1												20
21											1		21
Total	42	19	31	19	46	52	10	n/s	24	8	24	n/s	Total
Mean Age	11.7	11.1	9.8	7.3	9.2	10.9	12.7		12.1	7.9	10.3		Mean Age

n/s = Not sampled by this method.

(continued)

Table 3.1-24 (continued)
Age Distribution for Lake Trout by
a) Day Gillnetting, b) Night Gillnetting and c) Trapnetting

b) Night Gillnetting

Age (yrs)	Long	Leslie	Panda	Koala	Fox 1	Misery	Kodiak	Larry	Nema	Fox 3	Mike	Moose	Age (yrs)
3	4			1	1			2					3
4	18	1	4	1	3			1					4
5	24	5	6	5	8			2					5
6	11	4	6	3	4			2					6
7	2	3	6		7			4					7
8	5	1	5	2	5			6					8
9	1	1	2	1	11								9
10	1	1	3		7			4					10
11	12		1	1	9			3					11
12	5		1		9			5					12
13	8	2	2		3								13
14	7	2						1					14
15	3	2			2								15
16	2												16
17		1		1									17
18					1								18
19													19
20	1												20
21	1												21
Total	105	23	36	15	70	n/s	n/s	30	n/s	n/s	n/s	n/s	Total
Mean Age	8.1	8.8	7.3	6.9	9.0			8.5					Mean Age

n/s = Not sampled by this method.

(continued)

Table 3.1-24 (completed)
Age Distribution for Lake Trout by
a) Day Gillnetting, b) Night Gillnetting and c) Trapnetting

c) Trapnetting

Age (yrs)	Long	Leslie	Panda	Koala	Fox 1	Misery	Kodiak	Larry	Nema	Fox 3	Mike	Moose	Age (yrs)
3													3
4			1										4
5			1										5
6		2	2										6
7		1	2	1			1					1	7
8	3	2	5	1			3					2	8
9	3		12	3			3				1		9
10	7		8	6			2					1	10
11	6	2	8	9			5				1	1	11
12	6	3	11	3			8				1	1	12
13	9	2	5	10			4					3	13
14	5	4	9	4			6					1	14
15	4	3	1	3			1				1	2	15
16	6	2	3	2			5						16
17	5		3	1			1						17
18	7		1				1					1	18
19			1				4						19
20													20
21		1											21
22	1												22
23	1	1										1	23
24	1												24
Total	64	23	73	43	n/s	n/s	44	n/s	n/s	n/s	4	14	Total
Mean Age	13.8	12.9	11.3	12.0			13.0				11.8	12.9	Mean Age

n/s = Not sampled by this method.

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Table 3.1-25
Age Distribution for Round Whitefish by
a) Day Gillnetting, b) Night Gillnetting and c) Trapnetting

a) Day Gillnetting

	Long		Leslie		Panda		Koala		Kodiak		Little		Nema		Fox 3		Mike		Moose		
Age	**Scale**	**Oto**	**Scale**	**Oto**	**Scale**	**Oto**	**Scale**	**Oto**	**Scale**	**Oto**	**Scale**	**Oto**	**Scale**	**Oto**	**Scale**	**Oto**	**Scale**	**Oto**	**Scale**	**Oto**	**Age**
3	1										2										3
4	1		1		1						4		1				1				4
5					1		1		1		3		4		2		8				5
6	3	1	1		5	1			2	2		1	9		6	2	16				6
7	5	2	3	1	2	2	1		7		2	2	10		8	2	7	6			7
8	3	1	7	2	6	1	5		12	3	2		13	2	6	7	7	7			8
9	6	2	3	1	10	2		1	2		3		2	3	4	4	4	1			9
10			2		5	3	5	1	3		1		1	6		5	5	5			10
11			2	3	6	2	3	2		5	1			5				1			11
12	1	1	1	2		4		2		1	1	1		7		1		3			12
13		1				3	1			4				5				2			13
14						4		2		1				1							14
15								2		1				1							15
16				2		1		2		1	1										16
17						1		1						2							17
18				1																	18
19																					19
20																					20
21																					21
22																					22
23												1									23
24																					24
Total	20	8	20	12	36	24	16	13	27	18	20	6	40	32	26	21	48	25	n/s		Total
Mean	7.5	8.9	8.4	11.6	8.5	11.4	9.3	13.2	7.8	11.1	7.2	11.0	7.0	11.6	7.2	8.6	6.9	9.2			Mean

Oto= Otolith.
n/s= not sampled by this method.

(continued)

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Table 3.1-25 (continued)
Age Distribution for Round Whitefish by
a) Day Gillnetting, b) Night Gillnetting and c) Trapnetting

b) Night Gillnetting

	Long		Leslie		Panda		Koala		Kodiak		Little		Nema		Fox 3		Mike		Moose		
Age	Scale	Oto	Scale	Oto	Scale	Oto	Scale	Oto	Scale	Oto	Scale	Oto	Scale	Oto	Scale	Oto	Scale	Oto	Scale	Oto	Age
3	2				2																3
4	2				1		3														4
5	4				1																5
6	11	2			6		3														6
7	13	1			3	3		2													7
8	9	4			1	2	3	2													8
9	10	9					1														9
10	2	1			2		1														10
11		2						1													11
12						1	1	2													12
13		4																			13
14		1																			14
15					1																15
16		1				1		1													16
17																					17
18								1													18
19																					19
20																					20
21																					21
22																					22
23																					23
24																					24
Total	53	25	n/s		18	8	12	9	n/s		n/s		n/s		n/s		n/s		n/s		Total
Mean	7.0	9.8			6.8	9.3	7.1	11.0													Mean

Oto= Otolith.
n/s= not sampled by this method.

(continued)

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Table 3.1-25 (completed)
Age Distribution for Round Whitefish by
a) Day Gillnetting, b) Night Gillnetting and c) Trapnetting

c) Trapnetting and Aged by Scales and Otoliths

	Long		Leslie		Panda		Koala		Kodiak		Little		Nema		Fox 3		Mike		Moose		
Age	Scale	Oto	Scale	Oto	Scale	Oto	Scale	Oto	Scale	Oto	Scale	Oto	Scale	Oto	Scale	Oto	Scale	Oto	Scale	Oto	Age
3																					3
4																					4
5	4		1		1												5				5
6	10		3		7		4		7								8		2		6
7	15	1		2	6		2		4								4		4	1	7
8	5	3	2	1	6	1	7		4	1							2		5	1	8
9	11	3	1		7		4	1	2										2		9
10	1		3		4	2	5												3	1	10
11				2	1	1	2	3													11
12		2	2		1		1			1											12
13		1		1		1		5		3									1		13
14							1	2												1	14
15						1		1													15
16								2												1	16
17																					17
18								2												1	18
19																					19
20								1												1	20
21								1													21
22								1													22
23																					23
24																					24
Total	46	10	12	6	33	6	26	19	17	5	n/s		n/s		n/s		19	0	17	7	Total
Mean	7.3	9.5	8.5	9.5	8.0	11.2	8.8	14.8	7.1	11.8							6.2		8.3	13.3	Mean

Oto= Otolith.
n/s= not sampled by this method.

The oldest round whitefish recorded was 28 otolith years, captured in Little Lake, while the oldest age recorded by scales was 16 years. About 10% of the catch aged by otoliths were older than 15 years, while only 0.2% of those aged by scales were older than 15 years.

3.1.4 Size Distribution

In general, unimodal size distributions in all species were common for most day gillnetting and trapnetting sets, while night gillnetting yielded bimodal distributions in lake trout. Sample sizes for round whitefish (Appendix II-B12), grayling, burbot and longnose sucker were generally too small to reliably describe the size distribution of the population (Appendix II-B13).

Lake Trout

Modal size classes varied between populations and appears to be influenced by community composition and lake size (Figure 3.1-43). Lake trout from Long Lake had the widest length distribution and largest modal size (450 mm to 500 mm) than those from all other lakes studied. In small lakes, the size distribution was narrower, and the modal lengths were similar, ranging between 350 mm and 450 mm.

Night gillnetting yielded large numbers of juvenile lake trout in the catch which were rare in day gillnetting catches. Trapnetting consistently yielded a higher proportion of larger fish than index gillnetting. The size distribution in Long Lake for lake trout captured by different sampling methods illustrates how sampling methods affect the size distribution (Figure 3.1-44).

Mean size (fork length and weight) varied considerably between sampling methods for lake trout (Appendix II-B14). Mean size was usually greater in trapnetting catches than gillnetting because trapnets are more selective towards larger fish. Mean size for trapnetting ranged between 400 mm and 500 mm and for night gillnetting, ranged between 300 mm to 350 mm.

Round Whitefish

Modal size classes were remarkably similar between populations and areas (Appendix II-B13). Most round whitefish ranged within the 350 mm to 400 mm length class. The consistency between populations is further observed by the mean size, which varied little regardless of sampling method (Appendix II-B15).

3.1.4.1 Condition

Condition factors (length-weight relationships) describe the overall health (fitness) of a population. Age specific condition factors were generated for lake trout (fin ray age) and round whitefish (otolith age). Sample sizes for other

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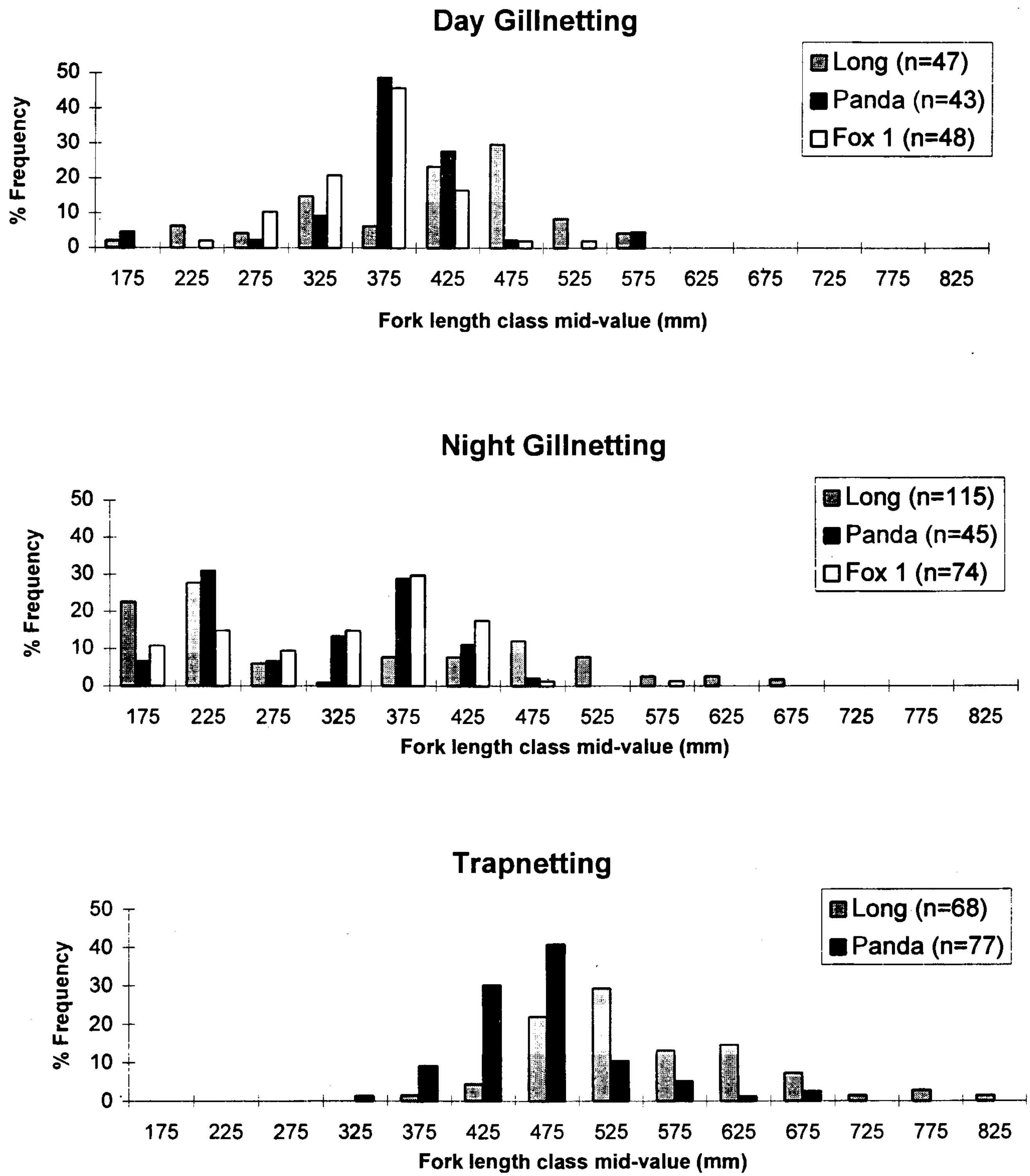
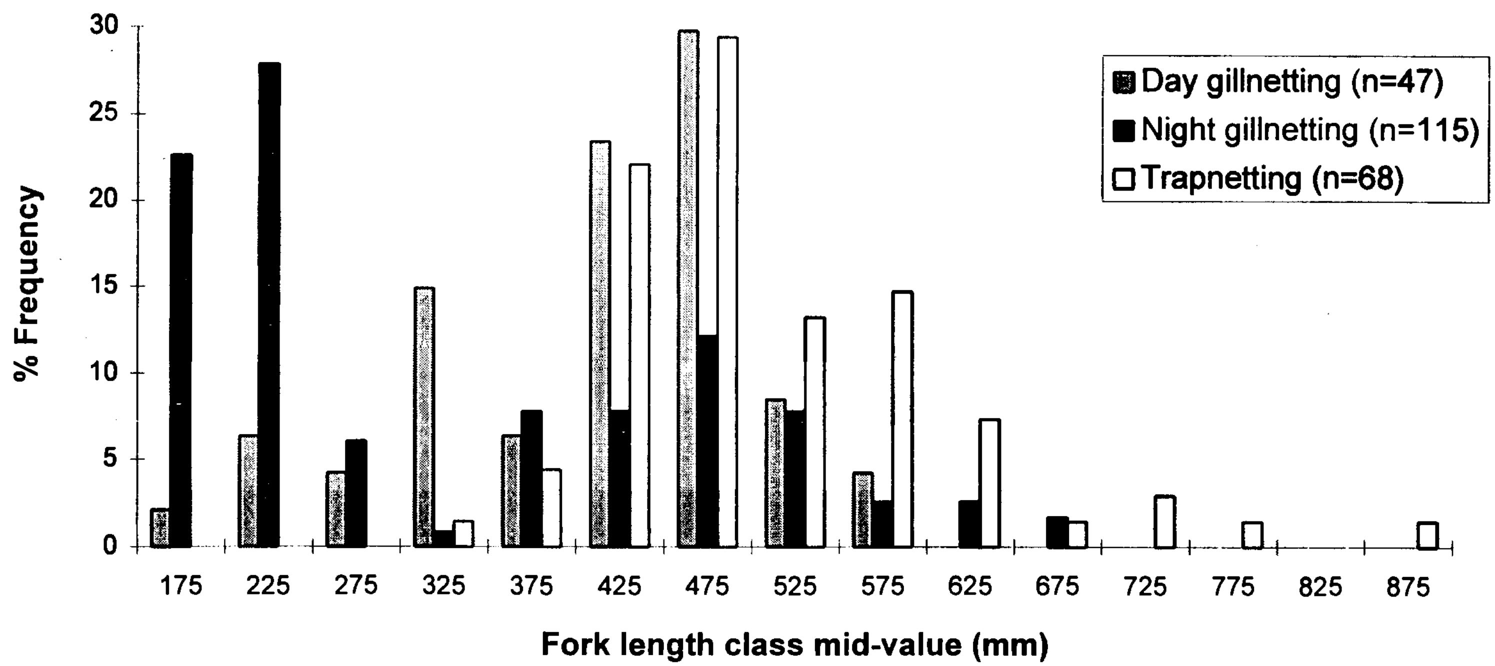


NWT DIAMONDS PROJECT

Figure 3.1-43
Fork Length Distribution (%)
for Lake Trout

Source: Rescan



NWT DIAMONDS PROJECT

Figure 3.1-44
Size Distribution for Lake Trout

Source: Rescan

species were insufficient to accurately describe condition. Condition factors for lake trout generally ranged between 0.90 and 1.20, with younger fish (<10 years) showing higher condition factors (1.10 to 1.20) than older fish (0.90 to 1.10; Appendix II-B16). Condition factors for round whitefish were more consistent throughout all age groups ranging between 1.05 and 1.20 (Appendix II-B16). Condition factors for different age classes and species were subject to high variation, as a result of low sample size and high variability between individuals. In addition, there was some variability in recording weights of live fish in the field.

3.1.4.2 Growth

Lake trout and round whitefish growth was compared among populations in the study lakes using age and length data collected in 1994. Sample sizes were insufficient to describe growth for arctic grayling, longnose sucker and burbot. Growth rates provide good indicators of productivity within a biological system. Lake trout growth was described using fin ray and otolith age while round whitefish growth was described using otolith age only (Appendix II-B17). Age determination from otoliths is generally considered to be one of the most accurate aging methods. However, to reduce mortality, the fin ray method was preferred. Since some otoliths were collected, comparisons have been made of ages estimated using the two different methods.

Lake Trout

Most lakes within the Koala drainage contain large, old fish. Fish are commonly up to 15 to 16 years old and may reach 24+ years. Mean size (length and weight) at age data are presented for fin ray and otolith aging methods (Appendix II-B18). There are no discernible differences in growth between lakes for lake trout up to ten years. Beyond this age, lake trout in Misery, Fox 1 and Larry lakes clearly exhibited slower growth than in other study lakes. Very few fish from these lakes exceeded lengths of 400 mm and weights of 400 g. Highest growth rates were seen in Long, Leslie, Kodiak, Mike and Nema lakes, which also contained the largest lake trout.

To compare growth rates by aging methods and between lakes two bench-mark length classes of 200 mm to 250 mm (mid-class length 225 mm) and 400 mm to 450 mm (mid-class length 425 mm) were established. The mean age for each length-class, as determined by each method, was calculated (Table 3.1-26a). For all lakes in the smaller length class, the mean otolith age was between 7.1 and 8.3 years with a range of six years to ten years. Fin ray ages were between 5.0 and 5.7 years, with a range of four and eight years. In each lake, otolith age is two to three years greater than fin ray age. However, neither method indicates any noticeable difference in mean age between lakes.

In the 425 mm length-class there is little difference between comparisons of aging structures (Table 3.1-26b). Fin ray analysis showed considerable variation in mean age and a wide range of individual ages within this length-class. Lake trout from Panda Lake had the lowest mean age (about ten years), but ranged from seven to 13 years. Lake trout from Misery Lake had the highest mean age and, therefore, the slowest growth rate (14 fin ray years, with ranges from 12 to 15 years). Lake trout from Long, Leslie, Koala and Fox 1 lakes were intermediate in age with means of about 12 years and ranging from nine to 15 years.

Table 3.1-26
Age at 225 mm and 425 mm Length Classes
for Lake Trout 1994

a) Age at 225 mm[1]

	Otolith Age					Fin Ray Age				
Lake	**Mean**	**Min.**	**Max.**	**S.D.[2]**	**N[3]**	**Mean**	**Min.**	**Max.**	**S.D.[2]**	**N[3]**
Long	7.7	6	9	0.9	12	5.1	4	8	1.0	33
Leslie	7.3	6	9	1.0	8	5.6	4	7	1.0	9
Panda	8.3	7	9	0.9	8	5.7	4	7	0.9	13
Koala	7.1	6	8	0.7	7	5.0	3	6	1.1	15
Fox 1	7.7	6	10	1.2	10	5.1	4	7	0.9	14
Misery	7.3	6	10	1.9	4	5.6	5	7	0.7	9

1: Length class of 200 mm to 250 mm. 2: S.D. = Standard Deviation. 3: N = Sample size.

b) Age at 425 mm[1]

	Otolith Age					Fin Ray Age				
Lake	**Mean**	**Min.**	**Max.**	**S.D.[2]**	**N[3]**	**Mean**	**Min.**	**Max.**	**S.D.[2]**	**N[3]**
Long	11.4	9	15	2.5	5	11.6	9	14	1.3	46
Leslie						12.4	11	14	1.3	11
Panda	12.0	12	12		1	10.2	7	13	2.0	13
Koala	12.0	12	12		1	11.8	9	15	1.8	34
Fox 1	14.0	12	16	1.6	4	11.8	9	15	1.5	22
Misery	15.0	15	15		1	14.0	12	15	1.4	5

1: Length class of 400 mm to 450 mm. 2: S.D. = Standard deviation. 3: N = Sample size.

Growth rates of lake trout in the study area appear to be very slow compared with lake trout populations in other lakes. Comparable data are available for lake trout populations in the NWT, northern Saskatchewan and northwestern Ontario. In Great Bear Lake (NWT), fish that were 430 mm in length were between eight and 11 years old. In Great Slave Lake (NWT), fish of comparable length were only five to six years old. In Lake Opeongo (northern Ontario), lake trout that were 410 mm in mean length were six years of age. In Lac La Ronge in northern Saskatchewan, 430 mm lake trout were only four years old (Rawson 1961). The only lake in which growth was similar to that in the study area was Kaminuriak Lake, NWT, where lake trout reached a mean length of 430 mm at 13 years (Martin and Olver 1980).

In the Koala watershed, a geographical trend is evident: 1) a relatively high number of large fish were found with relatively high growth rates in Long, Leslie, Moose and Nema lakes; 2) in Panda, Koala, Kodiak and Little lakes, growth was intermediate; and 3) in the headwater lakes (Fox 1 and Misery lakes) and Larry Lake, lake trout dominated the fish communities and growth was slowest. Juvenile lake trout in the study area exhibited similar growth rates, regardless of differences in lake area, volume, species composition and fish density. Juvenile growth seems to be limited by similar environmental or genetic factors in the study lakes. The diet of juvenile lake trout consists primarily of zooplankton and benthic invertebrates which, in turn, are limited by primary productivity and temperature. Low productivity combined with low water temperatures in northern lakes are probably the main factors limiting growth.

Adult growth was more variable than juvenile growth among the study lakes. Larger lake trout usually become piscivorous if forage species are available. This nutritionally improved diet stimulates increased growth, provided there is an abundance of forage species. Therefore, it might be expected that lakes which contain only lake trout (e.g., Misery and Fox 1) would have fewer adult piscivores, and slower growth compared to lakes with more diverse fish communities. This is evident in Misery Lake but not in Fox 1 Lake, where the mean age at 425 mm is similar to that of lake trout in multi-species lakes.

Round Whitefish

Mean length and mean weight at otolith age was generated for round whitefish up to 15 years of age (Appendix IIB-17). Growth between populations was less variable than with lake trout. Round whitefish reached 300 mm and 500 g by about seven years to ten years of age. Growth then slowed considerably, reaching a maximum size of about 400 mm and 800 g by about 15 years of age. Fish older than 15 years were captured in low numbers (oldest recorded at 39 years of age in Leslie Lake) but these did not exceed 450 mm and 1,000 g.

3.1.4.3 Reproduction

Five major fish species spawn in the study area. In the early spring, arctic grayling and longnose suckers spawn when ice begins to break up. Both species commonly spawn in streams, but longnose suckers may spawn in shallow areas of lakes (Scott and Crossman 1973). Lake trout spawn in the fall in shallow areas of lakes over silt-free boulder-cobble substrate. Round whitefish spawn in late fall usually after lake trout have finished spawning, and often after lakes have frozen over. Burbot spawn during late winter in shallow areas under the ice.

Arctic Grayling

Adult arctic grayling were sighted in high concentrations in several streams in early June while lakes were still mostly ice covered. Peak spawning activity occurs during maximum spring discharge, when temperatures range from 0 to 4°C (Rawson 1950; Reed 1964). In the Koala area study streams, fry had emerged from the substrate in large concentrations by July 15, and were still observed in the streams in mid-September, but in lower concentrations. Studies will be conducted in 1995 to identify more spawning sites for this species.

Longnose Sucker

Longnose sucker, normally a spring spawner, were not observed in large numbers in streams or lakes during 1994. Longnose suckers spawn in streams when water temperatures exceed 5°C, otherwise in shallow areas of lakes over gravel (Scott and Crossman 1973). Studies will be conducted in 1995 to identify the locations and timing of spawning for this species.

Lake Trout

Fall surveys were conducted in early to mid-September on three lakes (Panda, Fox 1 and Long) to identify habitat used by fall spawning fish. Lake trout spawning shoals were identified in Fox 1 (Figure 3.1-27) and Long lakes (Figure 3.1-31). In Fox 1 Lake, lake trout were observed spawning at dusk on September 16, 1994 over a shallow (1.5 m) cobble shoal. The surface water temperature was 8°C. Mainly ripe males and a few unripe females were captured at this site. The mean length of ripe males was 386 mm and mean age was 11 fin ray years (n=10). This may have been the end of the spawning period in this lake as no fish were observed the following evenings in the same area. Similar windswept shoals exist along the northwest shore of this lake which may also be used for spawning.

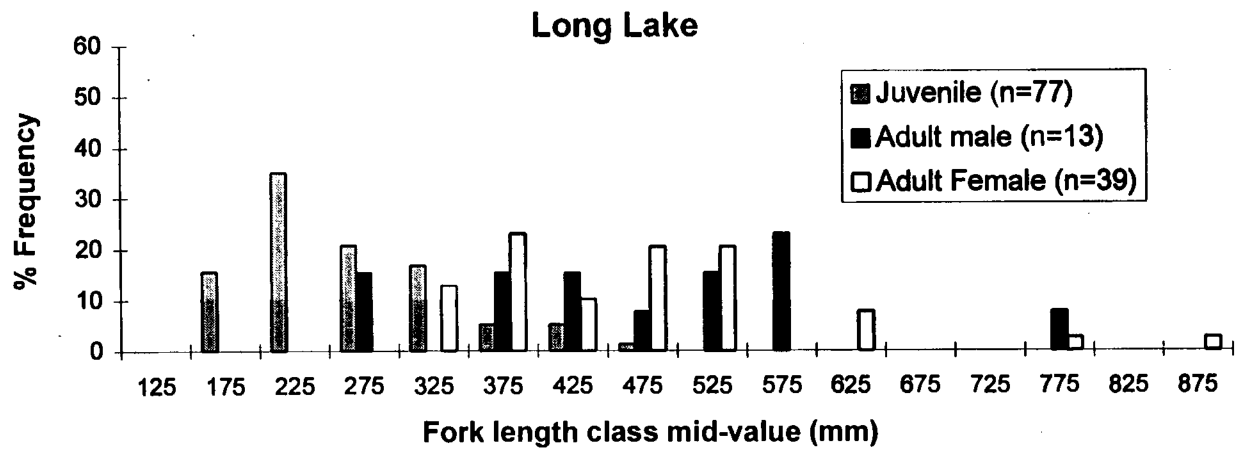
One spawning site was identified in Long Lake on the evening of September 17, 1994. This site was 2 m to 4 m deep, with clean cobble and boulder substrate. The shoal was adjacent to a small island comprised entirely of large boulders and was highly exposed to winds from all directions. Ripe females and several unripe fish of unknown sex were captured and tagged. The mean fork length of ripe females was 486 mm and mean age was 13 fin ray years (n=7). These fish were also likely observed near the end of their spawning period as no ripe fish were captured at this site in subsequent evenings. This site was on the windward side of the island which constitutes preferred spawning habitat for lake trout. There are probably several active spawning shoals on this large lake. Long Lake has a large area of littoral habitat consisting primarily of boulders, but some cobble areas do exist. Water temperatures on both lakes ranged from 6°C to 8°C, which are at the lower end of preferred spawning temperatures for lake trout (Martin and Olver 1980).

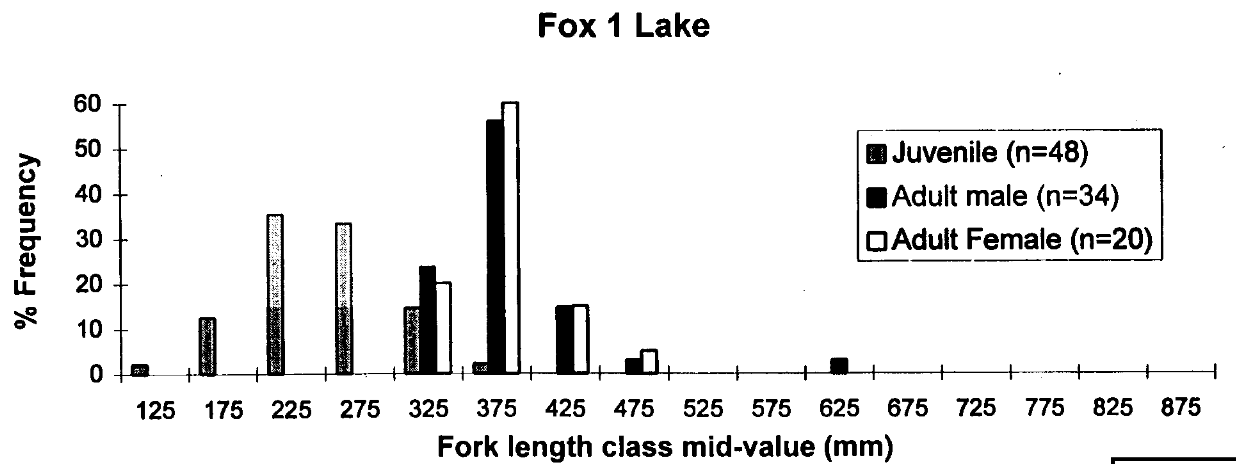
One ripe female was captured on September 4, 1994 in Misery Lake and one spent female on September 7, 1994. Water surface temperatures were 9°C and 7°C, respectively. Due to its remote location, this lake was not accessible for spawning surveys or evening netting. Spawning on this lake probably ends earlier than in Fox 1 and Long lakes as no evidence of spawning fish was observed in any other lakes during this time. These observations indicate that lake trout spawning periods in this area may be quite brief and are completed by mid-September.

It is likely that most lake trout were not spawning this year. Only a small number of ripe females were captured during the open water season. Lake trout tend to spawn every two to three years in northern lakes (McPhail and Lindsey 1970); therefore, only a relatively small portion of the lake population may be spawning in a given year. Females in northern fish populations may begin to develop eggs which fail to mature on time. Consequently, they are reabsorbed in the post-spawning period (Johnson 1972). In addition, in lakes where forage fish are scarce, infertility is higher (Martin and Olver 1976). The low abundance of small forage fish observed in the study lakes, suggests that lake trout fertility is more sporadic relative to lakes with a high abundance of suitable forage fish, such as lake cisco or smelt.

In the study lakes, males generally reached first maturity about one to two years before females (Appendix II-B19). Males reach maturity around eight to ten otolith years, while females reach maturity at nine to 11 otolith years. Most lake trout mature at ten to 12 otolith years. The average age of mature lake trout in the study lakes was similar to that found in Keller Lake, NWT (Johnson 1972, 1973), but younger than that found in Great Bear Lake (Miller and Kennedy 1948). Populations in more temperate regions mature earlier, at four to eight years (Martin and Olver 1980).

Size at first maturity varied between 300 mm and 400 mm fork length (Appendix II-B19). Most fish were mature at 450 mm. Mature fish in Fox 1 and Misery lakes are smaller relative to adult fish from Long, Leslie, and Panda lakes (Figure 3.1-45). In Fox 1 and Misery lakes, about 60% of the mature fish were between 350 mm and 400 mm. This difference may be a result of dietary habits, where lake trout forming single species communities in Fox 1 and Misery lakes have a smaller forage base and thus grow slower than lake trout within more diverse communities. Size at maturity for lake trout in the study lakes is similar to that found in plankton-feeding populations in the Algonquin Park lakes (Martin 1957) and is smaller than for most fish-feeding populations (Martin and Olver 1980).





NWT DIAMONDS PROJECT

Figure 3.1-45
Fork Length Distribution for Juvenile and Adult Lake Trout

Source: Rescan

Fecundity estimates for lake trout in the study lakes were not determined since few spawning females were captured and some were spent. In general, lake trout egg production is dependent on body size. Females can produce from about 0.9 to 2.6 eggs per gram of mature female (Scott and Crossman 1973). Average egg production for mature females from four lakes studied in the NWT ranged from 2.0 to 2.4 eggs per gram of body weight (Healey 1978a). In Ontario lakes, average egg production ranged from 1.5 to 1.8 eggs per gram of mature female.

Round Whitefish

Round whitefish were not observed spawning during the 1994 field season. Round whitefish are fall spawners like the lake trout; however, they often spawn later and under ice in northern lakes. Most round whitefish mature in Great Bear Lake by their sixth or seventh year and spawning occurs in autumn over gravel along lakeshores or in streams (Scott and Crossman 1973).

In the study lakes, both sexes reach first maturity at approximately the same age (Figure 3.1-46). Round whitefish reach maturity at six to nine otolith years, and most were mature by 13 otolith years. Size at first maturity was consistent between populations averaging 300 mm fork length (Appendix II-B20). Most fish were mature by 350 mm. Minimum size at maturity was similar in Lake Superior populations (Scott and Crossman 1973).

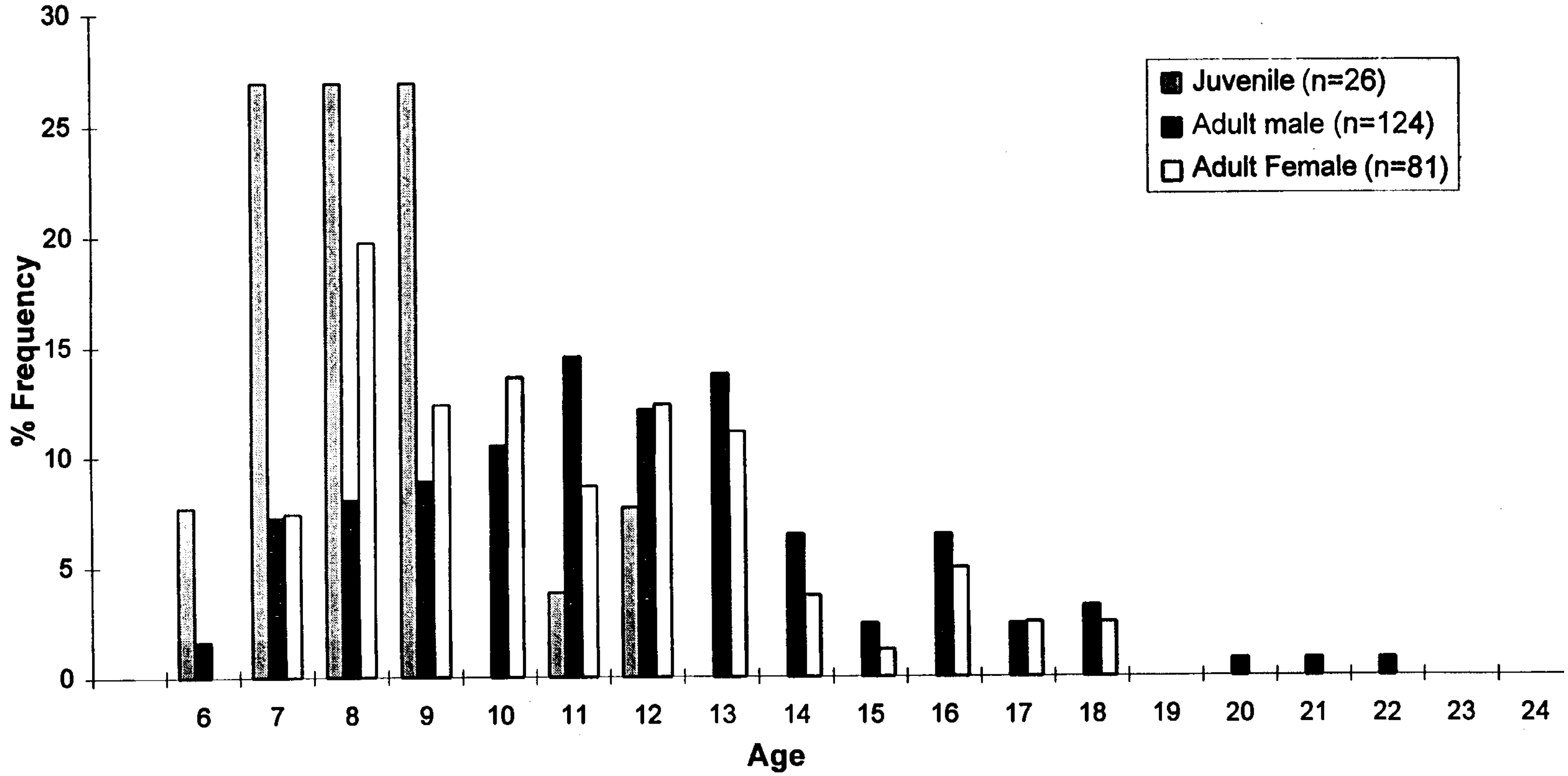
Little research has been done on the fecundity of round whitefish, since they are not a commercially valued species. The fecundity of round whitefish in Lake Superior was estimated between 2,461 to 10,459 eggs for mature females that ranged from 305 mm to 432 mm in total length (Scott and Crossman 1973). Average egg production was estimated to be 12 eggs per gram of mature female. Egg production for round whitefish is about six to ten times greater than for lake trout of the same size fish. However, lake trout are able to grow larger than round whitefish by about the same margin.

Burbot

Burbot spawn under ice in late winter and, therefore, the description of spawning behaviour from visual observations is very difficult. Sexual maturity is usually attained by the third or fourth year (Scott and Crossman 1973). Burbot spawn in streams or lake shallows at depths of 0.3 m to 1.2 m, usually over a gravel substrate (McPhail and Lindsey 1970). Young-of-the-year (YOY) burbot were common in streams during summer and fall, indicating that streams serve as important rearing habitats for this species.

3.1.4.4 Feeding Habits

Analysis of fish stomach contents is important for assessing ecosystem relationships. It shows the extent to which each fish predator in the system



Scale: 1:10 000

NWT DIAMONDS PROJECT

Figure 3.1-46
Age Distribution for Juvenile and Mature Round Whitefish

Source: Rescan

exploits the different prey species present. It also provides an assessment of the intensity of competition among predators, as well as the combined effect of all predators on each of the prey species. By monitoring changes in prey abundance, the effects on fish populations can be predicted. Fluctuations in the abundance of prey naturally affect the growth pattern, condition (relative fatness) and structure of the fish population, as well as influencing the timing and frequency of reproduction. Human changes in the abundance or seasonality of prey species can inevitably affect the structure of the predator population.

Fish stomach samples collected during the 1994 field season (June to October) from 16 study lakes are summarized by percent occurrence of food items and percent composition by number and weight of food items listed in Appendix II-B21. Percent occurrence refers to the frequency of a food item in the stomachs sampled. Only stomachs that contained food were submitted for analysis. Sample sizes were not large enough to divide samples according to season or fork length class, however, these results provide a good indication of the food consumed during the open-water period by a variety of size classes.

Fish may constitute a high proportion of the diet of large trout (>1 kg) which allows them to maintain their body size. Piscivorous lake trout feed on all fish species present (slimy sculpin, round whitefish, burbot and lake trout) except grayling (Table 3.1-27). They are the “top predator” in most lakes, although burbot may occupy a comparable position when present. However, due to the low number of burbot captured, none were sacrificed to determine feeding habits for this species. The fish diet of lake trout is supplemented by chironomids and cladocerans. Smaller size classes of lake trout are more dependent on benthic and planktonic organisms for food.

Piscivorous fish grow to a greater size than planktivorous fish because of the efficiency of capturing prey in larger energy units (MacLean *et al.* 1981). Cannibalism in lake trout was observed in several study lakes. Several large fish (>600 mm) captured in Panda, Moose, and Long lakes contained lake trout in their stomachs. Cannibalism in lake trout most often occurs in northern lakes (similar to the study lakes) where there is a limited number of forage fish (Martin and Olver 1980). In Great Bear Lake, nearly 3% of feeding lake trout (n=640) had consumed individuals of the same species (Johnson 1975).

The diet of round whitefish consists mainly of molluscs (snails and clams), crustaceans (cladocerans) and trichopterans (caddisflies; Table 3.1-27). In some study lakes, small fingernail clams, and the tightly coiled ramshorn snail (*Valvata sincera*) were found in considerable abundance. Round whitefish do not appear to feed on copepods, although they consume cladocerans, which are of similar size and abundance.

Table 3.1-27
Summary of the Major Groups of Organisms Consumed by Lake Trout, Round Whitefish and Arctic Grayling in the NWT Diamonds Study Lakes

Species	Lake	Site	Fish	Eubran-chiopoda	Arach-nida	Pelecy-poda	Gastro-poda	Trichop-tera	Coleop-tera	Ephemer-optera	Hemip-tera	Plecop-tera	Diptera	Cope-poda	Clado-cera
Lake trout	Larry	11	x					x					x		
	Long	19	x	x											x
	Little	23	x					x							x
	Leslie	17	x											x	x
	Kodiak	25	x												
	Fox 1	7	x										x	x	
	1-Hump	61											x		x
	Koala	27	x		x								x		
	Nema	62	x												x
	Panda	29	x										x	x	x
	Misery	48						x			x		x		
	Mike	2												x	x
	Fox 3	5	x												
Arctic grayling	Moose	15							x	x			x		
	1-Hump	61						x						x	
	Little	23												x	x
	Long	19							x				x	x	x
	Kodiak	25											x	x	
	Koala	27						x	x				x		
	Mark	46													x
	Panda	29									x		x	x	x
	Buster	60											x		
	Fox 3	5							x				x		
Round whitefish	Moose	15					x								
	Long	19				x		x							x
	Little	23	x					x					x		
	Leslie	17					x	x							x
	Kodiak	25				x	x	x							
	Koala	27					x	x	x			x			
	1-Hump	61											x		
	Panda	29				x		x					x	x	
	Nema	62				x	x								x
	Mike	2						x							x
	Fox 3	5				x	x								x

Arctic grayling feed primarily on insects (dipteran larvae) as well as crustaceans (copepods and cladocerans; Table 3.1-27). They do not feed on other fish, and do not appear to be consumed, as none were found among the stomach contents of either of the other two predators. It is possible that grayling contributed to the "unidentified fish remains" category. In addition, it may be that segregation into different habitats during the warm summer period, when lake trout tend to seek the coolest waters while grayling choose warmer regions, effectively reduces encounters between the two species. Round whitefish, burbot and slimy sculpin may have more frequent encounters with lake trout due to their close habitat associations and, therefore, may be preyed upon more frequently.

There is some dietary overlap among the three species analyzed. Cladocerans and dipterans (chironomids) were common prey organisms for lake trout, round whitefish and grayling. Chironomids dominate the benthos of the study lakes. The most significant time of consumption is during the period of emergence when the insect leaves the sediments as a pupa, then rises to the surface to emerge as a fully formed adult. During this period, large numbers are consumed by all fish species. In some cases, this is the main feeding period of the whole year. Similarly, the tiny cladocerans (about 1 mm in length), which were predominant in zooplankton tows, are an important food for all the fish species sampled. Chironomids and cladocerans are crucial to the efficient functioning of the whole ecosystem, especially in maintaining the health and well-being of the smaller individuals on which the upper level predators depend.

A small sample of fish stomachs analyzed from the project area in 1993 showed similar prey compositions for all three species. In addition, other studies in similar lake habitats revealed comparable feeding patterns. The diet of lake trout collected from Indin Lake, NWT, was dominated by fish and dipterans. Round whitefish collected in the same study were feeding on trichopterans, gastropods and dipterans, and grayling fed on dipterans, coleopterans and hymenopterans (Jessop *et al.* 1994). Lake trout and round whitefish in Toolik Lake, Alaska, consumed molluscs, although juveniles fed on crustacean zooplankton (O'Brien *et al.* 1979). Arctic grayling in Toolik Lake fed on zooplankton and insects (mainly chironomids; O'Brien *et al.* 1979).

Chironomid larvae were the major taxon consumed by grayling fry in several Alaskan streams, although terrestrial insects became more important as the fish matured (Northcote 1993). Grayling larvae stocked in Alaskan lakes fed primarily on chironomid pupae (Northcote 1993).

3.1.4.5 Trace Metal Analysis of Fish Tissues

Specimens of major fish species in each study lake were collected for trace metal analyses to document natural background levels. Elevated levels of trace metals can be deleterious to fish and consumers of fish. As a result, it is desirable to determine the level of these elements in fish tissues prior to the start of mining operations and to monitor the levels as mining progresses. A total of 13 trace metals of biological importance were analyzed.

Maximum, minimum and mean trace metal concentrations by species and tissue type for each lake sampled are presented in Appendix II-B22. Mean values and ranges for age, fork length and weight are also presented. A total of 145 fish were submitted for analysis (63 lake trout, 56 round whitefish, 23 grayling, one longnose sucker, one lake chub and one burbot). Concentrations for the 13 trace metal elements analyzed were based on wet weight. Parameter concentrations below the limits of detection were assigned values mid-way between zero concentration and the detection limit. This procedure provides an unbiased estimate of the mean for less-than-detectable concentrations, given that all readings between zero and the less-than-detection limit value are equally likely to occur (Gilbert and Kinnison 1981).

Mercury is the only trace metal with guidelines for human consumption established by Health and Welfare Canada. There are no set guidelines for other metals that relate directly to fish or fish consumption. Historically, Health and Welfare Canada advises DFO whether fish caught in certain areas are suitable for human consumption and whether restrictions on consumption are required to protect human health. Recommendations are made only when submitted samples show unusually high concentrations of trace metals and are specific to the case in question (Dalpe 1994).

The maximum allowable level of mercury in muscle tissue of fish sold in Canada for human consumption is 0.5 mg/kg (0.5 ppm) wet weight (CCREM 1993). However, a guideline of 0.2 ppm total mercury is recommended when fish constitutes a major subsistence food. Of the 12 lakes sampled, five had mean mercury values in muscle tissue >0.2 ppm. Some metals, including mercury, naturally accumulate in tissue over time. Therefore, older, larger fish may contain higher levels than younger fish (Bache *et al.* 1972). In Canadian fresh waters, naturally high concentrations of mercury have been found in lake trout (CCREM 1993). Only one of the fish analyzed, a 15 year old lake trout from Nema Lake, had a mercury value of 0.529 ppm which exceeds the 0.5 ppm guideline. The concentrations of most trace metals were generally higher in liver tissue than in edible muscle tissue.

Although toxicity guidelines for other metals in fish tissue are not available, there are numerous studies on the effects of various trace metals in water on a variety of fish species (Demayo *et al.* 1979, 1980; Demayo and Taylor 1981; Nagpal 1989; Reeder *et al*. 1979; Taylor and Demayo 1980). All trace metal levels in fish tissue from the 1994 studies appear to be comparable with fish captured in 1993 and fish from other unpolluted waters within the Northwest Territories (Baker Lake, Spyder Lake and Snare River; McKee *et al.* 1989).

Because anomalies can usually be identified in water samples before accumulations can be detected in fish tissue, the concentration in water is normally used to monitor trace elements in aquatic systems (McKenna 1994). In this regard, it should be noted that most water quality samples collected were within safe limits for the protection of aquatic life.

3.1.5 Summary

Seven species of fish were captured in lakes and streams within the BHP study area during the summer sampling programs in 1993 and 1994. In most lakes, particularly the larger ones, the dominant species, and the most valuable economically, is the lake trout followed by round whitefish and arctic grayling. Burbot is also present in some lakes in small numbers. Other species of little economic importance, but important to the lake ecology, are longnose sucker, slimy sculpin and lake chub.

Within the study area the fish species complement varies considerably from lake to lake, which is the result of specific environmental factors. The deeper the lake is, the more likely it is to have a single species population of lake trout. Lakes with the greatest number of species are intermediate in size and depth, but the greatest biomass is found in the smallest and shallowest lakes which contain only grayling.

Species composition and abundance in the streams varied with the season. During freshet, adult fish, predominately spawning grayling were found in streams. Low water levels in the summer allow only juvenile fish (arctic grayling, slimy sculpin, burbot) to occupy streams. In the fall, fish migrate to lakes as streams may freeze to the bottom in the winter.

The dominant environmental factor in these northern lakes is the annual formation and melting of the ice cover, as lakes less than about 4 m deep are unable to support fish populations. Substrate composition is similar among lakes, with rocky shorelines giving way to littoral zones of boulder and cobble, followed by silt at greater depths. The preferred habitat of lake trout for both feeding and spawning is the rocky littoral region of the lakes. Grayling also have abundant spawning and rearing areas in the rocky stream beds.

The fish in the area are slow growing, a result of low temperatures and very low nutrient status. The mean and modal size of adult lake trout in the Koala drainage lakes is between 400 and 500 mm, with ages averaging ten to 15 years. A second modal size class of smaller juvenile lake trout (200 to 250 mm) was encountered only in night gillnetting catches. Lake trout reach maturity at approximately ten years in the study area.

Population size estimates using mark-recapture techniques were determined for lake trout greater than 300 mm fork length from Panda, Koala and Misery Lakes. Panda Lake contained about 250 lake trout (seven fish/ha), Koala Lake contained about 110 lake trout (3 fish/ha), and Misery Lake contained about 90 lake trout (seven fish/ha).

There is some dietary overlap among species, however lake trout is the dominant predator in lakes, feeding on all fish species present except for grayling. Smaller size classes of lake trout are more dependent on the benthic and planktonic groups. Round whitefish are primarily dependent on molluscs and grayling feed mainly on insects (dipterans-chironmid larvae).

Trace metal levels in fish collected from the study area are similar to studies of fish in unpolluted waters in other areas within the Northwest Territories.

3.2 Vegetation

Vegetation represents a valued ecosystem component, as it provides the link between the physical and biotic components of the regional ecosystem. Local ecosystems, composed of distinct plant communities with their associated soils and fauna, exist in a relatively predictable fashion across the landscape. The wildlife study area represents an area of uniform regional climate where the ecosystem mosaic changes across the landscape in response to meso-scale environmental factors such as local climatic effects (snow accumulation areas, south-facing slopes), soil physical properties (texture, coarse fragment content, composition and porosity) and physiographic factors (slope position, angle and aspect). Vegetation contributes an important component of local biodiversity in an area of low species numbers. In addition to the plant species themselves, decomposing plant litter in ecosystem soils supports interdependent populations of small mammals, insects and soil micro-organisms. The different plant species that characterize each ecosystem type provide important components of biodiversity and habitat for the range of animals utilizing the wildlife study area.

The project wildlife study area is located approximately 80 km from the treeline in the Southern Arctic Ecozone, Takijua Lake Upland Ecoregion (Ecological Stratification Working Group 1995). Summer temperatures average 10ºC, with winter temperatures commonly below minus 30ºC. The area is also quite arid, with annual precipitation around 300 mm, about half of which falls as snow (Section 2.6). Vegetation communities that persist in arctic climates are adapted to the extreme cold and low precipitation that characterize the study area.

Vegetation in the wildlife study area is dominated in exposed upland areas by dwarf shrub communities composed primarily of dwarf birch, crowberry, lingonberry, Labrador tea and bearberry. Lag deposits of boulders have very thin soils and support lichen communities on exposed and fractured rocks. Low shrub and Sedge-tussock communities dominated by cottongrass are interspersed among dwarf shrub communities in upland areas. Tall shrub communities composed of green alder and willows occupy ravines where snow accumulates. Low-lying areas support a complex of water sedges and sedge-willow communities, and are common in low-lying depressions that connect lakes. Emergent communities of water horsetail and bulrushes occupy some shallow lakeshore margins.

Table 3.2-1 lists common plants found in the wildlife study area and references their common and scientific names. The ecosystems in which they are most prevalent and wildlife uses are also described for each species or group of species.

The growth and development of arctic tundra vegetation is constrained by low soil and air temperatures, drought or excess of soil water and nutrient availability, especially phosphorus (P) and nitrogen (N) (Truett and Kertell 1992). For much of the year, soils are frozen to the surface and no growth takes place. In the summer, soils thaw to create an active layer of various depths but soil temperatures remain cold. This combination of low air and soil temperatures results in very low rates of production for arctic vegetation. Very cold winter temperatures, along with strong and persistent winds, combine to dessicate and damage portions of plants exposed above the snow.

Soil water is often present in excess or is limiting to growth in arctic soils. In poorly-drained areas, high water tables limit plant production, develop organic soils and result in the development of wetland communities dominated by sedges and semi-aquatic grass species. In upland areas, coarse substrates that are rapidly drained are common. Along with the overall low summer precipitation, these factors limit the availability of soil moisture. This results in communities dominated by lichens and scattered, prostrate, vascular plants adapted to drought conditions. Although all required nutrients are present in arctic soils, low air and soil temperatures result in very low rates of organic matter decomposition. As a result, macronutrients such as N and P, which are available primarily from the decomposition of soil organic matter, cannot be utilized.

The objective of the ecosystem mapping is to provide an inventory of ecosystems within the wildlife study area. The biotic (flora and fauna) and abiotic (soils, climate, physiography) components combine to form a number of ecosystem types across the wildlife study area. A preliminary map of ecosystem types within the development area has been developed from 1:20,000 colour photographs and from field work carried out in 1994. This large composite map at 1:100,000 scale (Figure 3.2-1) is included in a pocket at the back of this volume. Large 1:10,000 scale maps covering the 1,900 km^2 wildlife study area will be available for review. The data are on a GIS computer system and are reproducible in colour depicting the various ecosystem units. Extensive ground truthing validation of the maps and the classification system will be conducted in July and August 1995.

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Table 3.2-1
Summary of Selected Characteristics for Common Plants in the Claim Block

Common Name	Scientific Name (s)	Ecosystem Units*	Wildlife Uses
Water sedges	*Carex aquatilis, C. chordorrhiza, C. rarifolia, C. rotundata, C. membranacea*	1,2	caribou, lemming forage
Cottongrasses	*Eriophorum angustifolium, E. scheuchzeri*	3,4	caribou, microtine forage
Grasses	*Arctagrostis latifolia, Arctophila fulva, Calamagrostis canadensis, Dupontia fisheri*	1,2,3,4	caribou, microtine forage
Dwarf birch	*Betula glandulosa*	2,4,6,7,8	ptarmigan; passerine birds
Willows	*Salix lanata* spp. *richardsonii, S. pulchra*	2,4,5,6	important food for ptarmigan, snowshoe hares, lemmings and caribou
Crowberry	*Empetrum nigrum*	4,6,7,8,9	important forage species for geese
Labador tea	*Ledum decumbens*	4,6,7,8,9	none
Lingonberry	*Vaccinium vitis-idaea*	4,6,7,8,9	forage for birds and mammals
Bilberry	*Vaccinium uliginosum*	4,6,7,8,9	forage for birds and mammals
Bearberries	*Arctostaphylos rubra, A. alpina*	4,6,7,8,9	forage for birds and mammals
Green alder	*Alnus crispa*	2,5,6	forage for birds and mammals
Licorice root	*Hedysarum alpinum*	10	important forage species for grizzly bear
Lichens	*Cladonia* spp., *Cetraria* spp.	6,7,8,9	forage for caribou

* Ecosystem Units within the wildlife study area (Table 3.2-2).

3.2.1 Previous Research

Although a wealth of information and research exists for vegetation studies for arctic landscapes in northern Canada and Alaska, none of these is known to have been conducted within the wildlife study area. Early work was primarily botanical; a history of plant collecting dating back to the Franklin expedition in 1821 is outlined in Porsild and Cody (1980). Ecological studies in the Arctic were initiated in conjunction with the increased exploration and development of arctic resources, primarily oil and gas. The two largest developments that have stimulated wide-ranging ecological and impact research have been the Mackenzie Valley pipeline proposal (Canadian Arctic Gas Study Ltd. 1974), along with the Aleyeska pipeline construction and development of the Alaska north slope (Aleyeska Pipeline Service Co. 1972). In particular, the development of the Alaska north slope area has resulted in a large number of research projects aimed at studying the impacts of industrial developments in tundra environments. A history and scientific review is presented by Walker *et al*. (1987). Other reviews of the environmental aspects of arctic oil and gas development are given in Brooks *et al*. (1971), Bliss and Peterson (1975) and Bliss and Wein (1972).

A number of classification systems have been developed to address biological description and land management concerns in arctic environments (Aleksandrova 1973; Bliss *et al.* 1973; Corns 1974; Hanson 1953; Hettinger *et al.* 1973; Larsen 1971; Young 1971). Ecological (Biophysical) Land Classification (Subcommittee on Biophysical Land Classification 1979) is another system widely used to produce maps of discrete soil-vegetation units in arctic landscapes (Tornocai and Boydell 1975; Zoltai and Pettapiece 1973). Bliss *et al.* (1976) have reviewed classification approaches and proposed a synoptic system to be utilized for the International Biological Program (IBP) in the Canadian Arctic. The main classes in the classification are Low Shrub, Dwarf Shrub Heath, Cottongrass-dwarf Shrub, Moist and Dry Meadow and Wet Sedge-grass. The classification system proposed by Bliss *et al.* (1976) has been adapted and applied as a starting point for description of ecosystems in the NWT Diamonds Project wildlife study area.

3.2.2 Methods

The classification system chosen is not to be confused with the mapping system. Ecosystem mapping is a land mapping system that has recently been developed in British Columbia (Ecosystems Working Group 1995). The system combines bioterrain mapping (Howes and Kenk 1988) and biogeoclimatic ecosystem mapping (Pojar *et al.* 1987) so that physiographic and biologic components of the landscape are integrated into one system. Ecosystem mapping provides a classification system that links potential impacts on soils to the vegetation communities associated with those soils. Ecosystem map polygons identify a natural classification of ecosystem units that can be used to generate interpretive maps. For example, ecosystems can be grouped into high, medium and low resource use for grizzly bear foraging, passerine bird habitat or ground squirrel habitat. Since the system is linked to surficial materials, ecosystem map units can also be coded for potential impacts such as susceptibility to damage by vehicular traffic, depth to permafrost or potential for mass wasting. These effects can then be directly related to impacts on animals that utilize the affected ecosystems as habitat.

Ecosystem mapping has not previously been applied to tundra ecosystems, but the same ecological principles that apply to forested ecosystems are operative in tundra ecosystems as well. The primary principles for delineating ecosystems are that, within an area of uniform climate, the availability of soil moisture and nutrients will control the distribution of plant communities. Soil moisture and nutrient regimes are in turn determined by physiographic components of the landscape such as the nature of surficial materials (soil texture, depth and coarse fragment content), slope and aspect, and the presence and depth of permafrost. These factors are integrated to delineate and interpret tundra ecosystems in the study area within the context of ecosystem mapping.

3.2.2.1. Bioterrain Mapping

Bioterrain mapping forms the basis for the ecosystem mapping system. Ecosystems are delineated by subdividing or agglomerating bioterrain polygons. Preliminary bioterrain mapping was carried out at a scale of 1:20,000 utilizing 1993 colour air photos. Mapping was based on the Terrain Classification System for British Columbia by Howes and Kenk (1988). This system is designed to provide an inventory of terrain features such as surficial materials, landforms and geologic processes. The combining of these symbols creates terrain unit symbols that describe terrain features and show their location, extent and distribution.

The surficial geology of the NWT Diamonds Project area has most recently been prepared by Rampton (1994) at a scale of 1:50,000. Regional terrain and unit descriptions adapted from Rampton are found in Section 2.1 and Table 2.1-1. Names used by Rampton may differ from those used in the Terrain Classification System because of slight differences in nomenclature between the two terrain mapping systems. For example, tills and moraines used in Rampton's system are grouped and classified as Moraine (M). Eskers would be F^{G}r, a glaciofluvial ridge.

3.2.2.2 Biogeoclimate Ecosystem Mapping

All ecosystem polygons are labelled on the map (Figure 3.2-1 in map pocket). As discussed above, pre-typing of tundra ecosystems was completed using a 1:20,000 colour photograph of the study area, on photos already pre-typed for terrain according to methods outlined by Mitchell *et al*. (1989) and the Ecosystems Working Group (1995). Using this approach, a map polygon may contain up to 15% "impurity", i.e., small areas that are different from the label of the polygon (Mitchell *et al*. 1989). Units too small to indicate separately have been grouped in complexes. Ecosystem and bioterrain lines from the photographs were digitized using an AP 190 stereoplotter and transferred to a 1:10,000 base map of the wildlife study area (1,900 km^2).

Tundra ecosystems in the wildlife study area have been divided into physiognomic groups and subgroups for the purposes of delineating ecosystems in the area (Table 3.2-2). Ecosystem polygons represent either pure units or composite units. When digitizing is completed, colour maps can be produced at any scale, and will show the distribution of tundra ecosystems and thematic interpretations of the ecosystem data, such as grizzly habitat, caribou foraging areas or susceptibility to vehicular traffic.

Table 3.2-2
Synopsis of Ecosystem Units

Physiognomic Group	Ecosystem Unit	
Sedge Tundra	1.	Sedge-grass
	2.	Sedge-shrub
Tussock Tundra	3.	Sedge-tussock
	4.	Sedge-tussock-shrub
Shrub Tundra	5.	Tall Shrub
	6.	Low Shrub
	6s.	Low Shrub/Cliff
Dwarf Shrub Tundra	7.	Open Mat
	8.	Open Lichen
	9.	Closed Mat
Herbaceous Tundra	10.	Herbaceous Tundra
Emergents	11.	Emergents

3.2.2.3 Preliminary Description of the Ecosystem Units

A total of 11 ecosystem units are distinguished for the wildlife study area (Table 3.2-2) and make up six physiognomic groups. The classification is preliminary and is based on existing literature from other studies conducted on arctic terrain (Bliss *et al*. 1975) and limited field sampling in the Lac de Gras area in 1994. The classification will be refined in 1995.

Regional precipitation and summer temperatures are generally uniform within the wildlife study area. Vegetation is controlled by soil moisture and nutrition, which are largely influenced by small-scale variation in topography.

Physiognomic Groups

Sedge Tundra (Ecosystem Units 1 and 2)

Sedge Tundra are wet meadows that are found on organic soils in depressions, in drainage areas between or adjacent to lakes and on low, gentle slopes. Wetlands are a major component of this ecosystem. Sedge meadows are dominated by semi-aquatic sedges (*Carex* spp.) and cottongrass (*Eriophorum* spp.), with willows (*Salix* spp.) and dwarf birch (*Betula glandulosa*) found on hummocks and other raised portions of the meadow. Mosses such as *Sphagnum* spp., *Drepanclades* spp. and *Aulacomnium* spp. offer form and continuous cover in Sedge Tundra ecosystems. There are two types of Sedge Tundra, which are distinguished by shrub coverage: Sedge-grass (Unit 1) and Sedge-shrub (Unit 2). Areas of Sedge Tundra are common but scattered and rarely extensive in size. Sedge Tundra ecosystems are important for summer grazing of caribou and for shorebirds and waterfowl because of the abundance of shallow pools and small lakes. These areas also support creatures such as lemmings as well as mammals and bird predator species.

Tussock Tundra (Ecosystem Units 3 and 4)

Tussock Tundra is found on organic veneers (<1 m thick) in depressions in upland tundra and on low, gentle slopes between wetland meadows and upland tundra. Gleysols are the predominant soils. The prevalent vegetation is cottongrass, which is complemented with sedges and hummocks supporting Labrador tea (*Ledum decumbens*), lingonberry (*Vaccinium vitis-idaea*), dwarf birch and bilberry (*Vaccinium uliginosum*). Tussock Tundra exists in a continuum with wet tundra. Two types of Tussock Tundra are recognized: Sedge-tussock (Unit 3) and Sedge-tussock-shrub (Unit 4). Like Sedge Tundra, Tussock Tundra provides important summer grazing areas for caribou. Microtines, ptarmigan and species of passerines also forage in this area.

Shrub Tundra (Ecosystem Units 5, 6 and 6s)

Two types of Shrub Tundra exist, Tall Shrub (Unit 5) and Low Shrub (Unit 6). Tall shrub communities (up to 2 m in height) are dominated by willows (*Salix planifolia* and others), dwarf birch and green alder (*Alnus crispa*). Areas of Tall Shrub Tundra are common around seepage areas in streams and springs that are subject to considerable snow accumulation. Tall Shrub ecosystems provide important browse for snowshoe hare and provide cover for wolves and bears. Passerine and ptarmigan bird populations nest and seek shelter in Tall Shrub.

Low Shrub communities are found less frequently. They tend to be on the leeward slopes of cliffs and eskers. Common species include dwarf willows, dwarf birch, Labrador tea, crowberry (*Empetrum nigrum*) and *Vaccinium* spp. Low Shrub ecosystems on steep cliffs have been identified as Low Shrub/Cliff (Unit 6s) because of their potential importance as raptor nesting sites. Low Shrub ecosystems are important for microtines, ptarmigan and several species of passerines. They can support arctic ground squirrel colonies where communities develop on deeply-thawed sands and gravels. Caribou use these ecosystems as a source of food, but not as frequently as the Sedge-grass and Sedge-tussock types.

Dwarf Shrub Tundra (Ecosystem Units 7, 8 and 9)

Dwarf Shrub Tundra is found on well-drained uplands with shallow snow cover. Soils are typically Brunisols. Three types of Dwarf Shrub Tundra or "upland tundra" have been identified: Open Mat (Unit 7), Open Lichen (Unit 8) and Closed Mat (Unit 9). The distinguishing feature between the three tundra types is the amount of vegetation (percent) growing. For instance, if vegetation cover is more than 75%, it is considered Closed Mat. However, if the coverage is less than 75%, yet continuous, it is considered Open Mat, whereas Open Lichen is patchy.

Open Mat exists on morainal till veneers (<1 m thick), rocky uplands, boulder fields and eskers. It is the most prevalent ecosystem unit in the Dwarf Shrub Tundra, covering extensive and continuous portions of the landscape.

Open Lichen is found on exposed bedrock where lichens and scattered dwarf shrubs are almost the only vegetation. Areas of Open Lichen Tundra are common but not extensive.

Close Mat is also found on morainal till blankets (>1 m thick) covering rocky uplands, but with less frequency than Open Mat. Due to lower plant cover, low production and exposed locations, Dwarf Shrub Tundra has relatively little value as wildlife habitat. There is limited usage by passerines and microtines.

Herbaceous Tundra (Ecosystem Unit 10)

Herbaceous Tundra (Unit 10) is found on rocky, sandy areas, esker slopes and enriched microsites such as animal dens. Common species include arctic willow-herb (*Epilobium latifolia*), wormwood (*Artemisia* spp.) licorice-root (*Hedysarum alpinum*), prickly saxifrage (*Saxifraga tricuspidata*) and variegated horsetail (*Equisetum variegata*). This ecosystem unit is very localized and cannot be distinguished by air photo interpretation.

Emergent Wetlands (Ecosystem Unit 11)

Emergent Wetlands (Unit 11) are found occasionally in lakeshore shallows where the substrate texture is sufficiently fine to permit rooting. Common plant species include water horsetail (*Equisetum fluviatile*), *Arctophylla fulva* and bulrushes (*Scirpus* spp.). Emergent plant communities are not common in the study area.

Summary

The initial investigative research for the vegetation baseline study was based on air photo interpretation of the terrain within the claim block and has resulted in a preliminary ecosystem map. During field research in the summer of 1995, the information will be refined and any rare plant species or anomalies will be noted.

The predominant vegetation type is the dwarf shrub communities in exposed upland areas. Low Shrub and Sedge-tussock communities are scattered between the dwarf shrub communities. Lichen communities are found where there are very thin soils and fractured rocks. Tall Shrub communities occupy ravines where snow accumulates and water sedges and sedge-willow ecosystems are found in depression areas that connect lakes. Water horsetail and bulrushes occupy the lakeshore margins.

3.3 Wildlife

Wildlife and wildlife habitat have been identified as valued ecosystem components. In particular, two wildlife species and one habitat element were the focus of most concerns expressed during scoping meetings: barren-ground caribou (*Rangifer tarandus*), grizzly bears (*Ursus arctos*) and eskers.

Most wildlife species at Lac de Gras are migratory, and the migrations occur during spring through fall. Lac de Gras lies within the migratory pathway of the Bathurst caribou herd. Wolves (*Canis lupus*) follow the caribou, and some den in the Lac de Gras area during the summer. Arctic fox (*Alopex lagopus*), red fox (*Vulpes vulpes*) and wolverine (*Gulo gulo*) are present in the area all year, as are grizzly bears. Small mammal species such as ground squirrels (*Spermophilus parryi*), lemmings (*Lemmus* spp.), voles and mice either hibernate or are active under the snow. Arctic hares (*Lepus arcticus*)) are active all year. The only bird species found year-round are ptarmigan (*Lagopus* spp.).

Muskox (*Ovibos moschatus*) are uncommon at Lac de Gras. The majority of the muskox in the world are found in the NWT (Graves and Hall 1988). These animals are found on most arctic islands, along the coast and may be present in some areas as far south as treeline. Historic numbers and distribution were greatly reduced across the barren lands during the last century. Due to protective measures implemented in the late 1920s the muskox population has been expanding (Graves and Hall 1988). There was one sighting of six muskox at Lac de Gras during the summer of 1994 and, during 1995, four animals were observed in the area. Given recent conservation practices, numbers of muskox at Lac de Gras may increase in the future.

A number of species found within the Lac de Gras area have been accorded special designation by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). The risk categories of COSEWIC are extinct, extirpated, endangered, threatened and vulnerable (Munro 1990). Endangered is defined as "a species threatened with imminent extinction or extirpation throughout all or a significant portion of its Canadian range." Threatened refers to "a species likely to become endangered in Canada if the factors affecting its vulnerability are not reversed." Vulnerable refers to "a species particularly at risk because of low or declining numbers, small range or for some other reason, but not a threatened species."

Two mammal species in the Lac de Gras area have been designated as vulnerable by COSEWIC: grizzly bear and wolverine. Of the bird species observed to date, only the Peregrine Falcon has been accorded special designation. The tundra subspecies (*Falco peregrinus tundrius*), which was seen at Lac de Gras, is designated as vulnerable. The anatum subspecies, *F.p. anatum*, is designated as endangered. This subspecies lives primarily in the western Northwest Territories.

A number of species recorded at Lac de Gras are included in Appendix II of the Convention on the Conservation of Migratory Species of Wild Animals. These are "Migratory species with unfavourable conservation status and which require international agreements for their conservation and management." All species on the list have been observed at Lac de Gras except for the Black Scoter (*Melanitta nigra*).

3.3.1 Study Areas

The objectives for studies were to examine the occurrence and movements of wildlife within the immediate vicinity of the proposed mine development and the surrounding region. Two study areas were designated (Figure 3.3-1). The local study area was approximately 100 km^2 and included the NWT Diamonds Project exploration camp, the portals at Fox and Koala lakes and the six lakes that will be affected by the project. These are Long Lake, to be used for tailings deposition, and Panda, Misery, Koala, Leslie and Fox 1 lakes, to be used for mine development.

The larger study area was 1,900 km^2, bounded on the north by Exeter and Ursula lakes, on the east by Lac du Sauvage and the Coppermine River and on the south by the north shore of Lac de Gras. This area is referred to as the wildlife study area. Air and ground access was provided by a Bell 206B helicopter based at the NWT Diamonds Project exploration camp. Within the Koala watershed, access was also provided by foot, truck and boat.

3.3.2 The Bathurst Caribou Herd

Lac de Gras lies within the migratory pathway of the Bathurst caribou herd (*Rangifer tarandus groenlandicus*). The Bathurst herd constitutes one of five

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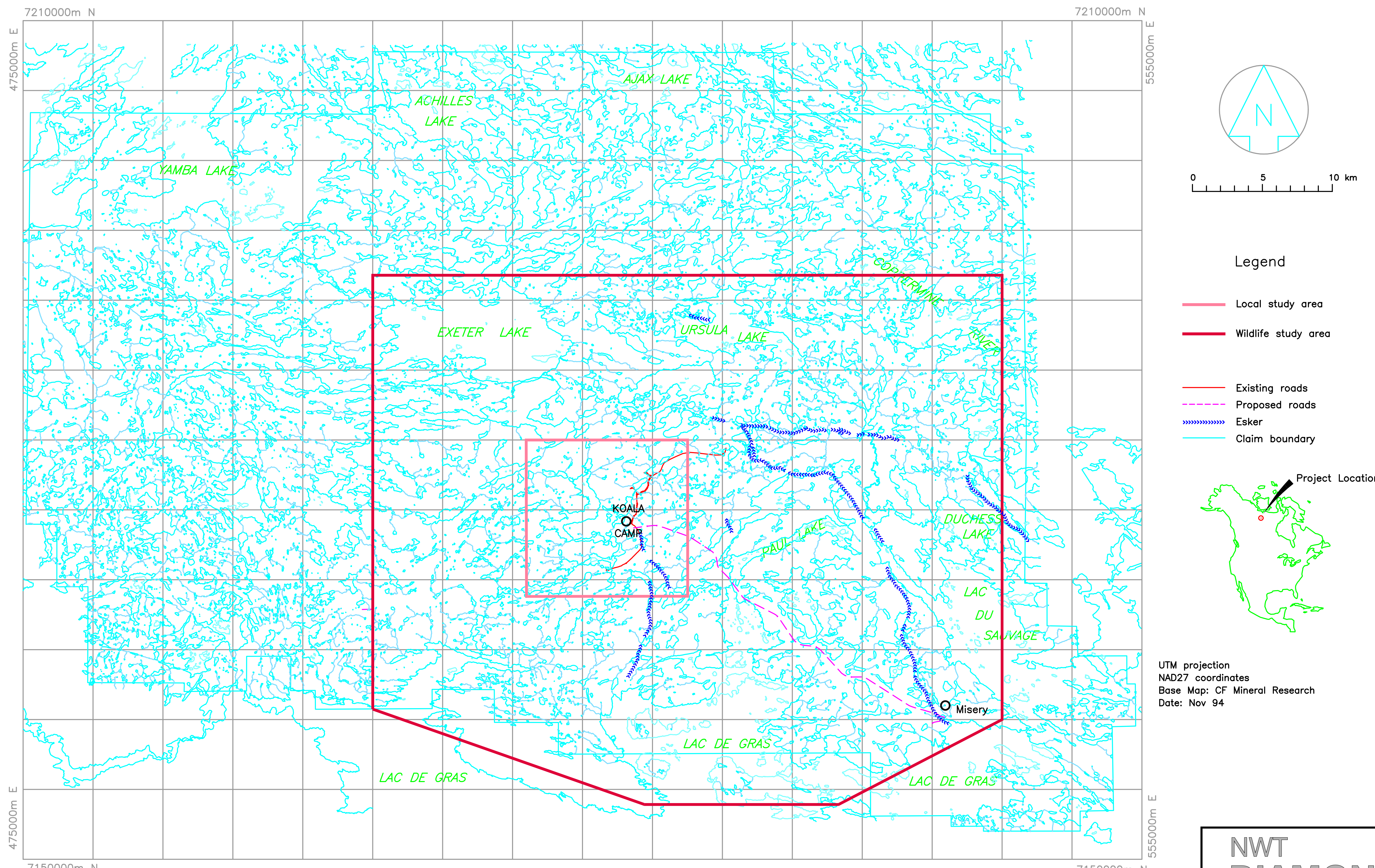

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Figure 3.3-1
Study Areas Used for Wildlife Studies, 1994

Source: Rescan

major mainland herds of barren-ground caribou in the Northwest Territories. It is the largest and most accessible to people than any of the others.

Barren-ground caribou have been identified as a Valued Ecosystem Component due to the pivotal role they play in the lives of Aboriginal people and other residents of the Northwest Territories. Caribou are a source of healthy food and caribou hides provide clothing and shelter. Bones, teeth and antlers are used for art, which is sold internationally. Hunting trips which are structured around the availability of the herd, provide an important opportunity for Dene to renew their spiritual and physical connection to the land. Thus, caribou are an integral component of the traditional land-based economy. The harvest of these animals by sports hunters also enables Aboriginal people to earn incomes from guiding operations.

Field investigations during 1994 attempted to determine the numbers and movement patterns of caribou within the Lac de Gras area, especially the identification of important movement corridors.

Caribou migrate through the Lac de Gras area during spring and fall. In 1994, herds of 100 to 700 or more caribou per day passed through the proposed development area during migration. Lac de Gras is not known as either summer or winter grounds for caribou (Heard 1989). In 1994, caribou grazed within the Lac de Gras area during the summer but none were observed in winter.

3.3.2.1 Traditional Knowledge of Caribou

Caribou remain the single most valued animal to the Dene of the region:

"Of particular importance are the caribou, which migrate through the (proposed mining) area, and which we harvest in the spring and fall when they are in their wintering area below the treeline. The food from these harvests is stored in a community freezer and shared throughout the community. The caribou is very important to our people. How will they be affected? Will they move around the area, or will it (the mine) change their migration route?" (Fred Sangris, Yellowknives First Nation 1995).

"*Caribou are our mainstay, it feeds us, and plays a big role in perpetuating our status as Yellowknives Dene"* (Chief Darrell Beaulieu, Yellowknives Dene First Nation 1995).

Inuit have also traditionally depended on the Bathurst Caribou herd, especially in the Contwoyto Lake area. In earlier times, after the introduction of the repeating rifle, large reserves of caribou meat would be cached for use throughout the winter at Contwoyto Lake. Here, caribou played an important role in the trapping economy, as fox traps would be set around caches (Farquharson 1976). Today, Inuit from the Bathurst Inlet area depend heavily on caribou from this herd, which is hunted from late spring to mid-summer around the head of Bathurst Inlet.

Dene, Metis and Inuit are familiar with the spring and fall migration patterns of the caribou, and know where and when caribou can be most easily intercepted and hunted. They can also perceive distinctions in behaviour and morphology rarely apparent to outsiders and are extremely knowledgeable of natural long-term fluctuations in availability. For example, biologists became concerned in the 1970s that dwindling caribou herds of the Keewatin region could not support existing levels of hunting. Even though the Inuit and Chipweyan did not share this view, strict regulations were being considered when biologists discovered that the supposedly most endangered herd, the Kaminuriak, increased from a low of 40,000 to 200,000 animals in a matter of two years. In other words, scientific estimates were incorrect and concerns of overhunting and imminent extinction were misplaced. Since then, Aboriginal people and biologists have worked together to ensure that there will always be enough caribou to meet the needs of local communities.

Based on knowledge of areas previously used and abandoned by caribou, Inuit understand why caribou populations increase and decrease and where they will do so (Brody 1976). Dene today remain familiar with the migration routes of caribou through the area (e.g., Johnson and Ruttan 1993) and the locales where caribou are most easily intercepted (Andrew Gon, elder, Rae Lakes).

According to traditional knowledge, there appear to be two major migration routes for caribou in the Lac de Gras area: one along the north shore of Lac de Gras, and the other between Lac de Gras and the north end of MacKay Lake. These two major migration routes have been documented in Appendix I-A1. The area between Lac de Gras and MacKay Lake, or Ek'ati tata, appears to have been an especially favourable location for the hunting of caribou:

"the area between the Ek'ati and N'qdixati (MacKay Lake) is known as Ek'ati tata...which translates as the land between two lakes...is important because this strip of land creates a funnel through which the caribou travel between the two lakes, creating an important hunting site. People live in this area because it is where the caribou route leads. They are easy to hunt from this spot" (Suzie MacKenzie, cited in Appendix I-A7).

Figure 3.3-2 documents the area where Dene and Metis traditionally hunted caribou from late fall to late winter in the region. Particularly obvious in this regard is the heavy use of Ek'ati tata. Beginning in late October/early November, Dene would enter the barrens via two travel routes on the Yellowknife River basin to Courageous and MacKay lakes. Here, they would establish camps where fish was in good supply and wood was available, and set traplines and hunt caribou in Ek'ati tata. The abundance of glacial features (eskers, drumlins, etc.) between the

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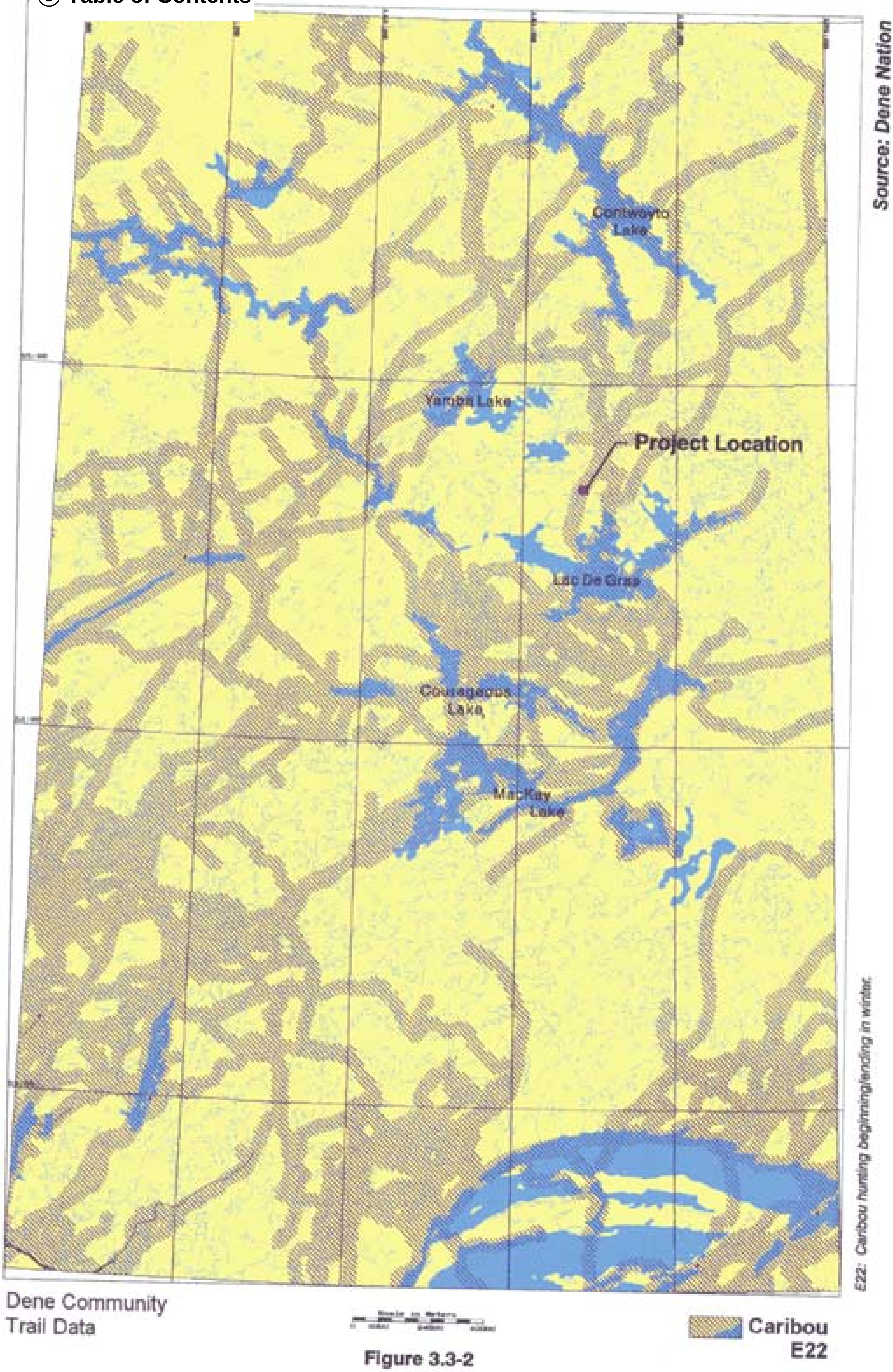

Figure 3.3-2

north end of MacKay Lake and the east end of Lac de Gras (Figure 2.1-2) appears not only to have been an important site where caribou were intercepted during the fall migration (Figure 3.3-2), but an important denning site for wolf and fox (Appendix I-A1:Map Four). While this combination of attributes made Ek'ati tata attractive to human use, the area north of Lac de Gras was, in comparison, not as heavily hunted (Figure 3.3-2) or as heavily trapped (Figure 1.2-5).

Figures 3.3-3, 3.3-4 and 3.3-5 illustrate the areas where caribou were traditionally hunted during the fall, spring and summer, respectively. Caribou hunting in the fall and spring was much more concentrated than during the winter. This may have been due to the possibility that fall caribou hunting was task-specific, i.e., not carried out in conjunction with other activities such as fox trapping and fishing, and/or due to the fact that caribou during the early spring/late winter are located within the treeline. Caribou hunting during the summer, however, appears to be less concentrated.

Aboriginal elders not only know the locations where caribou can be most easily hunted, they are familiar with the behaviour and migration patterns of this animal:

"They start from Bathurst (Inlet) about...around the last week in July, and then they start their migration and then about the 25th of July to the first of August they will hit Pellet Lake and go along Contwoyto Lake and they go around and head for Fort Rae, maybe a hundred miles" (Archie Mandeville, Yellowknife).

But Aboriginal elders also know that the movements of caribou are not always predictable:

"*Caribou, they change their route just about every year anyways. They change their route. They look for good feed*" (Stan Laroque, Yellowknife).

"*...The migration is not always on line there, sometimes there are no animals at all, period. They are over the coast by Coppermine and through there, and they go to Bear lake and they go to the Dempster Highway*" (Archie Mandeville, Yellowknife).

Implicit in the above statement is the suggestion that the Bathurst caribou herd sometimes mixes with the Bluenose Lake caribou herd and perhaps others as well. In fact, because of the irregular movements of the Bathurst caribou herd, some elders interviewed regarded the Lac de Gras area to be a marginal area for caribou hunting:

"*Lac de Gras is kind of a bad place (for caribou) because sometimes you get caribou and sometimes you don't. There were trappers that lived there years ago, maybe 50 or 60 years ago, White trappers. They go out there and they just about starve(d) because the caribou don't come; they change(d) migration"* (Archie Mandeville, Yellowknife).

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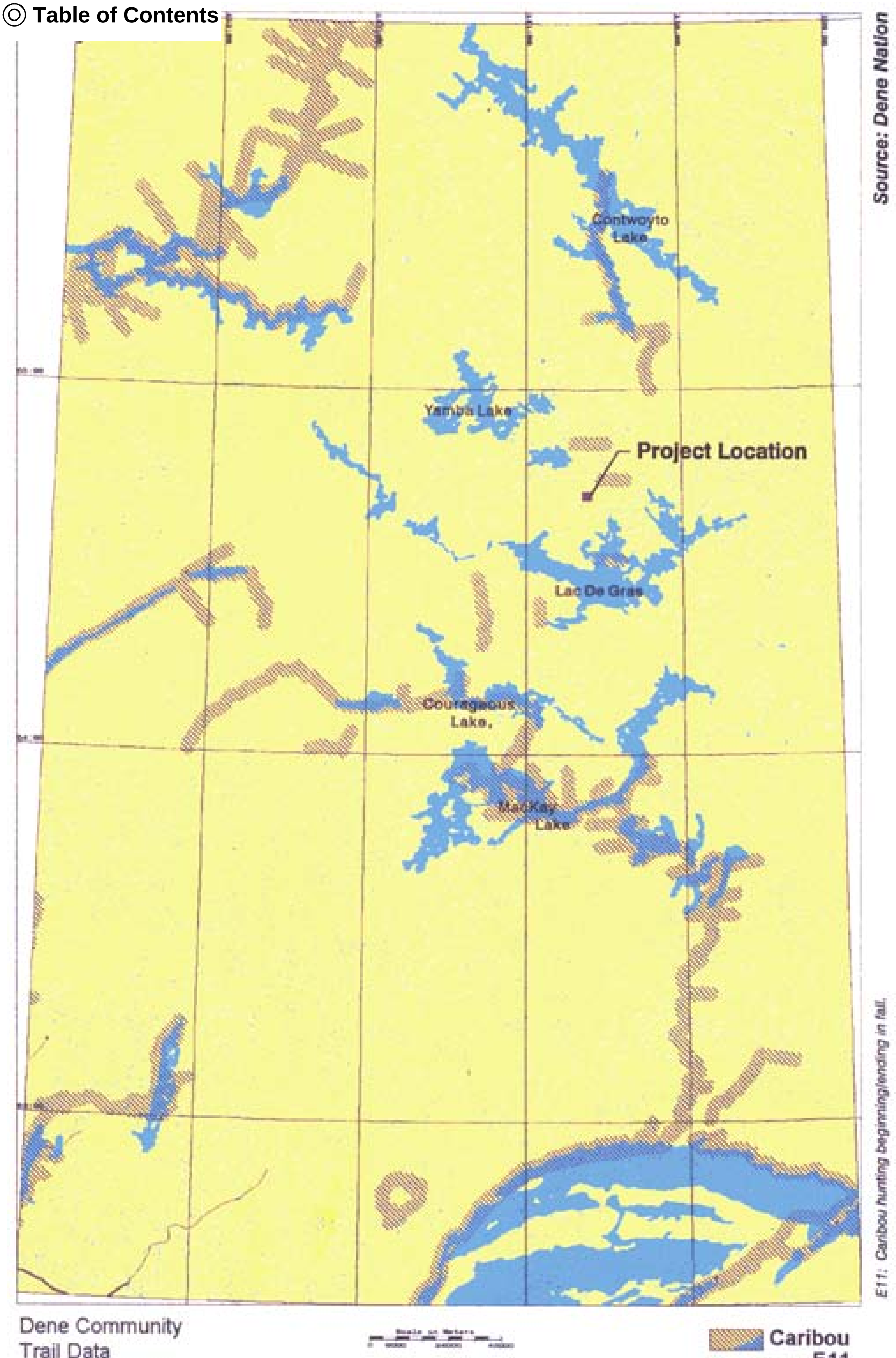

Dene Community Trail Data

Figure 3.3-3

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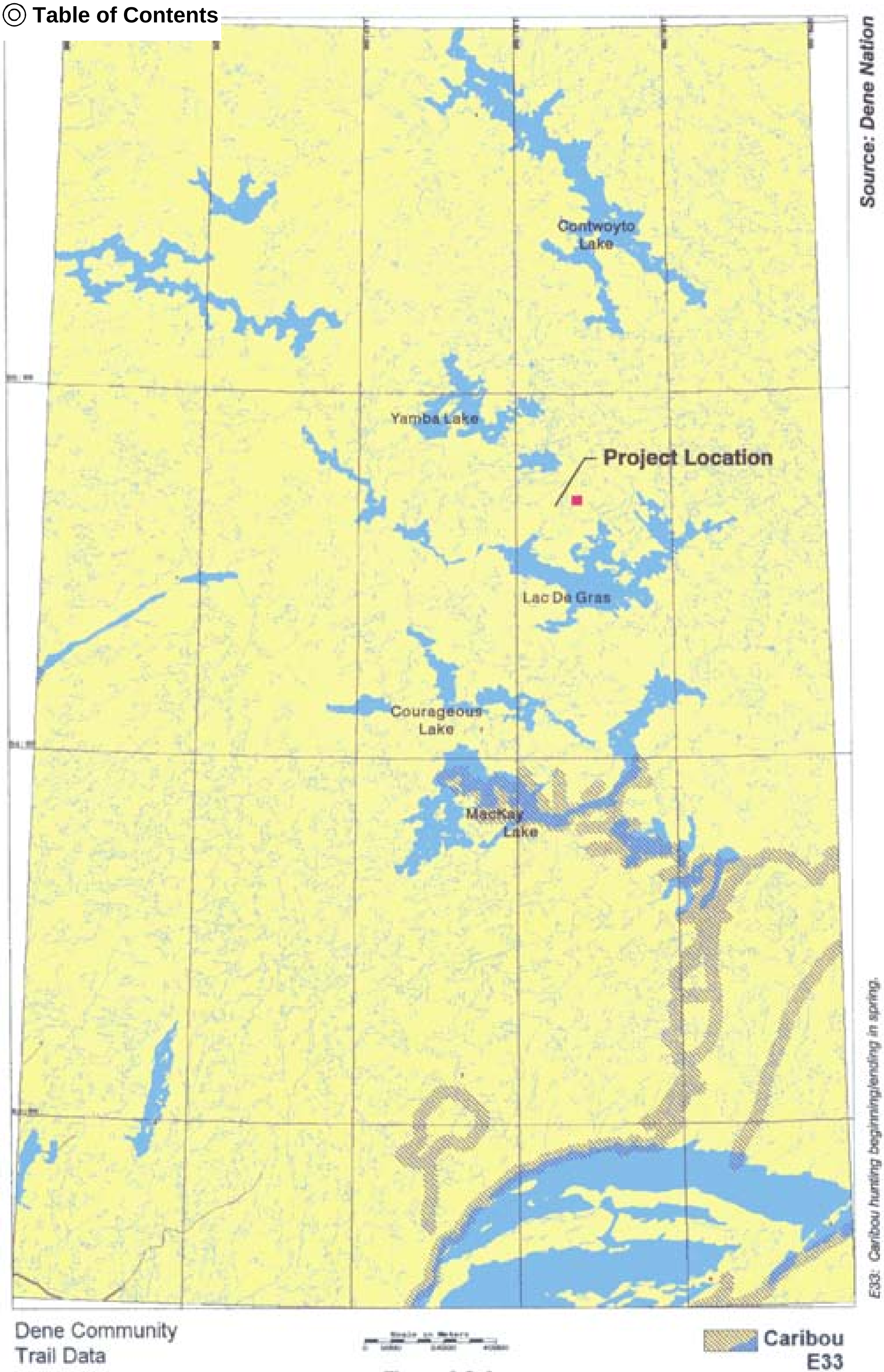

Figure 3.3-4

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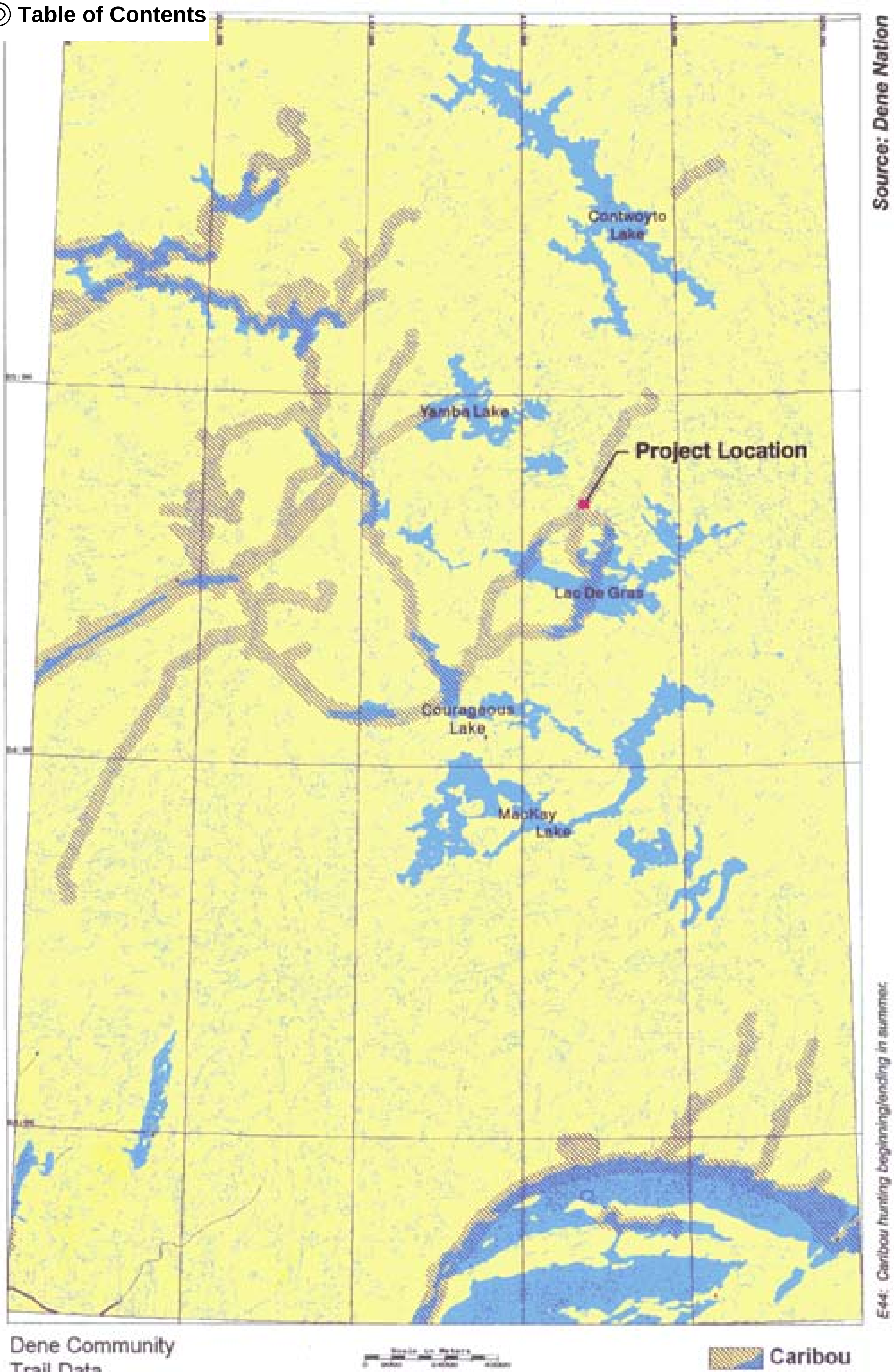

Dene Community Trail Data

Figure 3.3-5

It is also important to point out that, even though efforts to document traditional ecological knowledge of caribou have only just begun, what knowledge has been obtained appears to complement and support the two years of work undertaken by wildlife biologists in the area.

3.3.2.2 Previous Research

Bathurst caribou currently occupy a range of about 250,000 km^2 (Figure 3.3-6) although all portions of the range may not be used each year (Renewable Resources 1988). Despite the common perception that barren-ground caribou are migratory with distinct patterns of movements, the herd comprises individual animals, and perhaps groups, that choose from a variety of options for movement throughout the year (Urquhart 1981). As there are few barriers to movement, with the possible exception of large lakes such as Contwoyto and Point lakes in the fall, migration corridors tend to vary from one year to the next.

The distribution of caribou is commonly grouped into five separate phases based on the prominent movements of the most mobile segments of the herd. These movements are spring migration, calving grounds, summer movements, fall migration and winter range.

Any large-scale movements of caribou after mid-February are considered to be a part of the spring migration. Routes followed by the taiga wintering herds are a function of topography, snow conditions and the location where caribou concentrate in late winter. Specific routes used each year may be unique, although they are paths that have been used for centuries (Urquhart 1981). Responses to government questionnaires issued during 1934 to 1948 suggest the Lac de Gras area was historically one of the common routes used by caribou during spring migration (Urquhart 1981).

Since about 1960, the majority of cows calve in one particular area east of Bathurst Inlet (Urquhart 1981). Pregnant cows and some yearlings arrive in the vicinity of Bathurst Inlet any time from late April to the first week of June (Fleck and Gunn 1982). If the spring migration is impeded by environmental conditions, such as snow and freezing rain, calving can occur en route (Urquhart 1981). The earliest calving date appears to be May 30, and the peak calving period is June 5 to 10 (Fleck and Gunn 1982).

Summer and fall movements are the most poorly documented of all seasonal patterns. There is no clear distinction between the end of nomadic summer movements and the beginning of movements toward winter ranges (early July to early November; Urquhart 1981). A widespread movement of caribou towards the treeline begins in July or early August.

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Figure 3.3-6
Range of the Bathurst Caribou Herd

Source: Heard 1989

Winter range is the area occupied after the fall migration, during late November to about mid-March. Some caribou winter on the tundra (Urquhart 1981), but the most frequent wintering areas are around Hottah Lake, Gordon Lake, McLeod Bay, Artillery Lake and Dismal Lake (GNWT 1988). Small groups may be found anywhere from Bathurst Inlet to Great Slave Lake (Heard 1989).

Traditional crossings are important areas. They are formed where caribou are diverted because of open or fast-moving water. Crossings tend to be used during the fall because in the spring open water is typically frozen. Water barriers are the only sites where caribou are forced to use the same movement corridors from year-to-year.

One such corridor, used by caribou in late July and early August, is along the shores of Contwoyto Lake. Contwoyto Lake is perpendicular to the movement of caribou from Bathurst Inlet and caribou must diverge either north or south to continue moving south westward. Caribou choosing to cross to the south of Contwoyto Lake intercept Lac de Gras and Lac du Sauvage. They must cross between the two lakes or route around Lac du Sauvage. This crossing has probably been used for hundreds of years by caribou and was used by Aboriginal people for hunting of caribou (Pike 1892).

Although lichen are an important food source in the winter, caribou are opportunistic and eat whatever vegetation is available. During the summer, caribou take advantage of new plant growth including grasses, forbs, sedges and the leaves and branches of dwarf willow and birch (Urquhart 1989). In the fall, they add fungi to the diet and continue to feed on vascular plants as long as they are available.

The range of the Bathurst herd encompasses a wide variety of habitat types, including taiga, treeline, inland tundra and coastal tundra. Habitat use by caribou is complex and a function of many environmental factors. In addition to forage availability and snow conditions, habitat selection is based on the presence or absence of insects, predators and other caribou. Wide open areas are used as escape terrain and resting sites (Kelsall 1968). In the summer, eskers and other high ground are used to provide relief from insects and for travel.

Fires affect the distribution of plant species and succession of vegetation communities. Terrestrial lichen species require particularly long recovery periods after fire. As such, natural fire may influence the distribution and movement of caribou (GNWT 1988). The extent of fires within the wildlife study area in 1994 was minimal.

No large-scale mortality of caribou on the mainland Northwest Territories has ever been linked to an epizootic disease outbreak or to extreme parasite loads (GNWT 1988). However, two insect species, the warble fly (*Oedemagena* sp.) and the nasal bot fly (*Cephenmyia* sp.), are parasites of major significance for caribou.

Insect harassment governs the use of habitats as caribou seek escape terrain, influences the size and dispersion of groups as caribou band together to avoid insects, and can cause caribou to seek out human developments such as roads and airstrips. High parasite loads normally are not a direct cause of mortality but they may increase the probability of death by other factors (Urquhart 1989). This is especially true if the harassment is so intense that very young or old caribou cannot meet their nutritional needs.

Natural adult mortality rates for the Bathurst herd are not known. However, similar to other herds, mortality rates will range from 8% to 10% (Renewable Resources 1988). The wolf is the only major predator of caribou in the Northwest Territories (Kelsall 1968; Heard and Williams 1992). Grizzly bears are infrequent predators (Kelsall 1968; GNWT 1988).

There are few observations of rutting within the Bathurst herd and those available have been confined to the southwest extremity of the range. These observations suggest rutting is at its peak approximately between October 20 and 31 and ends by about November 7, with occasional clashes between young males until around November 25 (Urquhart 1981). The rut may take place anywhere within the population's range except the southernmost extremities of the taiga winter ranges.

There are no estimates of the prehistoric size of the Bathurst herd. Moreover, it is difficult to attach much credibility to historical records of caribou abundance because of the variability in movements. From 1948 to 1967, ten attempts were made to estimate the number of caribou on the Bathurst range, producing estimates between 100,000 to 300,000 (Urquhart 1981). Survey methods were imprecise with highly variable estimates. Population estimates derived from complete range surveys were discontinued after 1967 in favour of calving ground surveys (Heard 1989). Between 1965 and 1980, nine surveys were conducted on the calving grounds by the Department of Renewable Resources. The 1982 count resulted in an estimate of 160,000 to 200,000. The 1984 survey estimated a population of almost 400,000, and the 1986 survey resulted in an estimate of 486,000. The increase over four years was believed to be largely due to an influx of caribou from other herds (Heard 1989).

3.3.2.3 Methods

Spring migration information was obtained from a reconnaissance survey of the wildlife study area flown on May 2 and 3, 1994. Five 2 km wide transects and the Lac du Sauvage esker were flown using a Twin Otter aircraft at a speed of 200 km/h and elevation of 300 m to 400 m. Numbers of caribou and their positions were recorded on a 1:50,000 topographic map.

Within the local study area, caribou surveys were undertaken every two to four days from July 23 to September 10, 1994. Nine 1 km wide transects, each 9 km in length, were established using GPS (Global Positioning System) in a north-south direction (Figure 3.3-7). Transect lines were flown at 44 km/h to 50 km/h at an elevation of 30 m. The pilot and recorder noted any caribou seen directly ahead of the aircraft. Two observers on either side of the helicopter searched 500 m wide transects and called out sightings. The recorder noted locations and numbers of caribou on 1:50,000 or 1:250,000 topographic maps. On September 17, 1994, the local study area was incorporated into the wildlife study area.

Within the wildlife study area, survey transects were flown weekly starting July 21 to the end of the fall migration in October 1994. Using GPS, eleven 1 km wide transects, 17.5 km to 26.3 km in length, were established in a northeast to southwest direction (Figure 3.3-8), which is the general direction of caribou movements. Survey methodology was the same as for the local study area. For both areas, caribou were classed as bull, cow, calf or unknown using antler size and the presence of a calf.

Incidental Wildlife Sightings

A second source of information was obtained from incidental observations recorded by Rescan biological staff, helicopter pilots and residents of the NWT Diamonds Project site. These data were recorded on a wildlife log maintained at the exploration camp. Due to the number of people and the extent of their activities, incidental observations became a supplemental source of information to the planned surveys.

Analysis

To determine caribou movement patterns, the wildlife study area was divided by the compass directions into four quadrants, northeast, northwest, southeast and southwest (Figure 3.3-9). The local study area falls within the southwest quadrant.

Caribou sightings were analyzed separately for the proposed Misery haul road. Data are presented for caribou occurrence within a corridor of 5 km, 2.5 km on either side of the proposed road. Incidental and survey results were combined for this analysis.

3.3.2.4 Numbers and Distribution of Caribou

Exploration, baseline studies and tours provided many opportunities for caribou observation throughout 1994. Although it is likely that not all wildlife observed were reported, the high degree of interest by camp personnel, coupled with education efforts, resulted in 178 individual reports from January to November 1994. Of these reports, 46 were of caribou ranging in number from one to 1,500. Although the opportunity for incidental observations was greatest in the vicinity of the NWT Diamonds exploration camp, personnel reported sightings from all

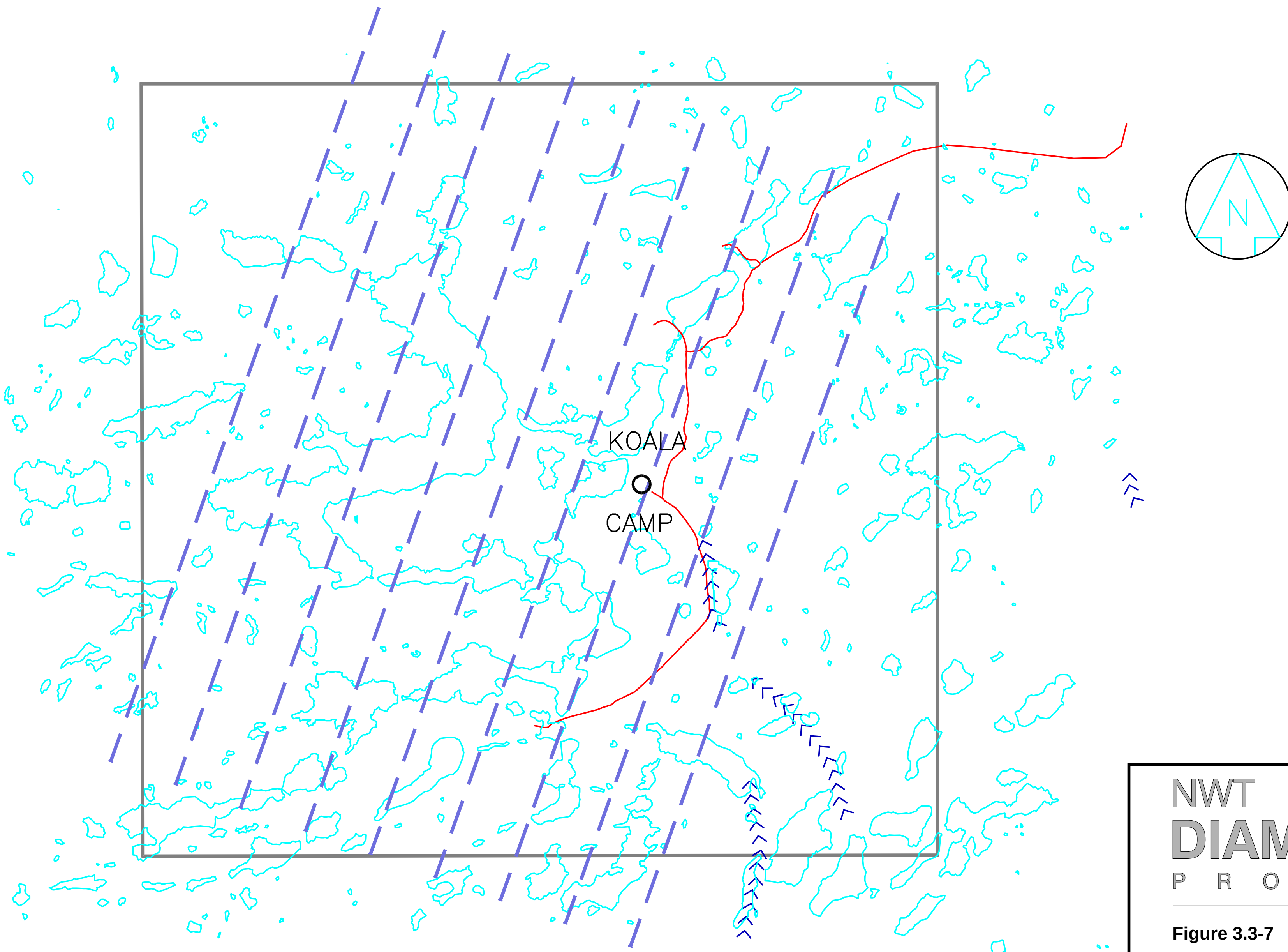

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Figure 3.3-7
Transects for Caribou Surveys
Local Study Area, 1994

Source: Heard 1989

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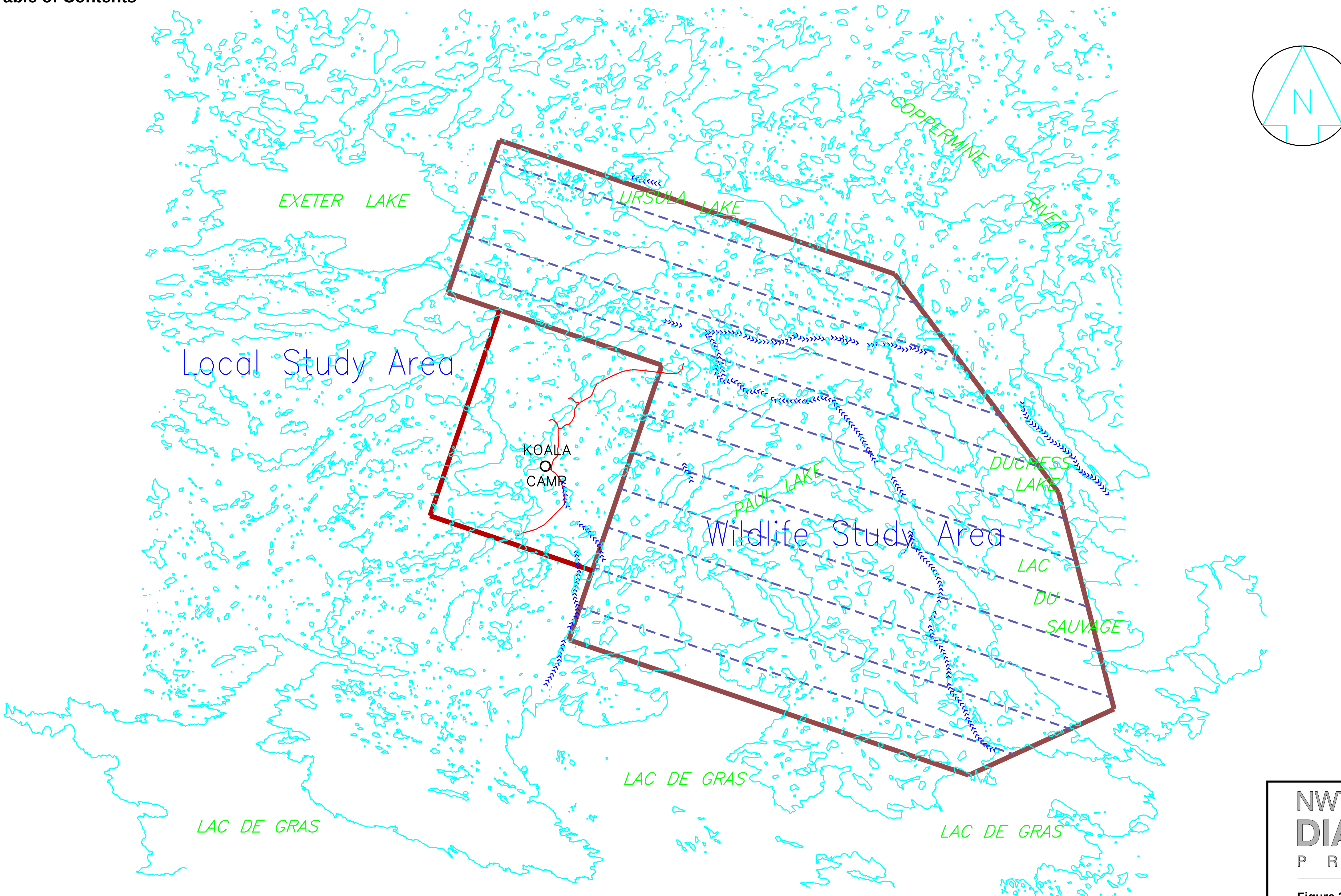

NWT DIAMONDS PROJECT

Figure 3.3-8
Transects for Caribou Surveys
Wildlife Study Area, 1994

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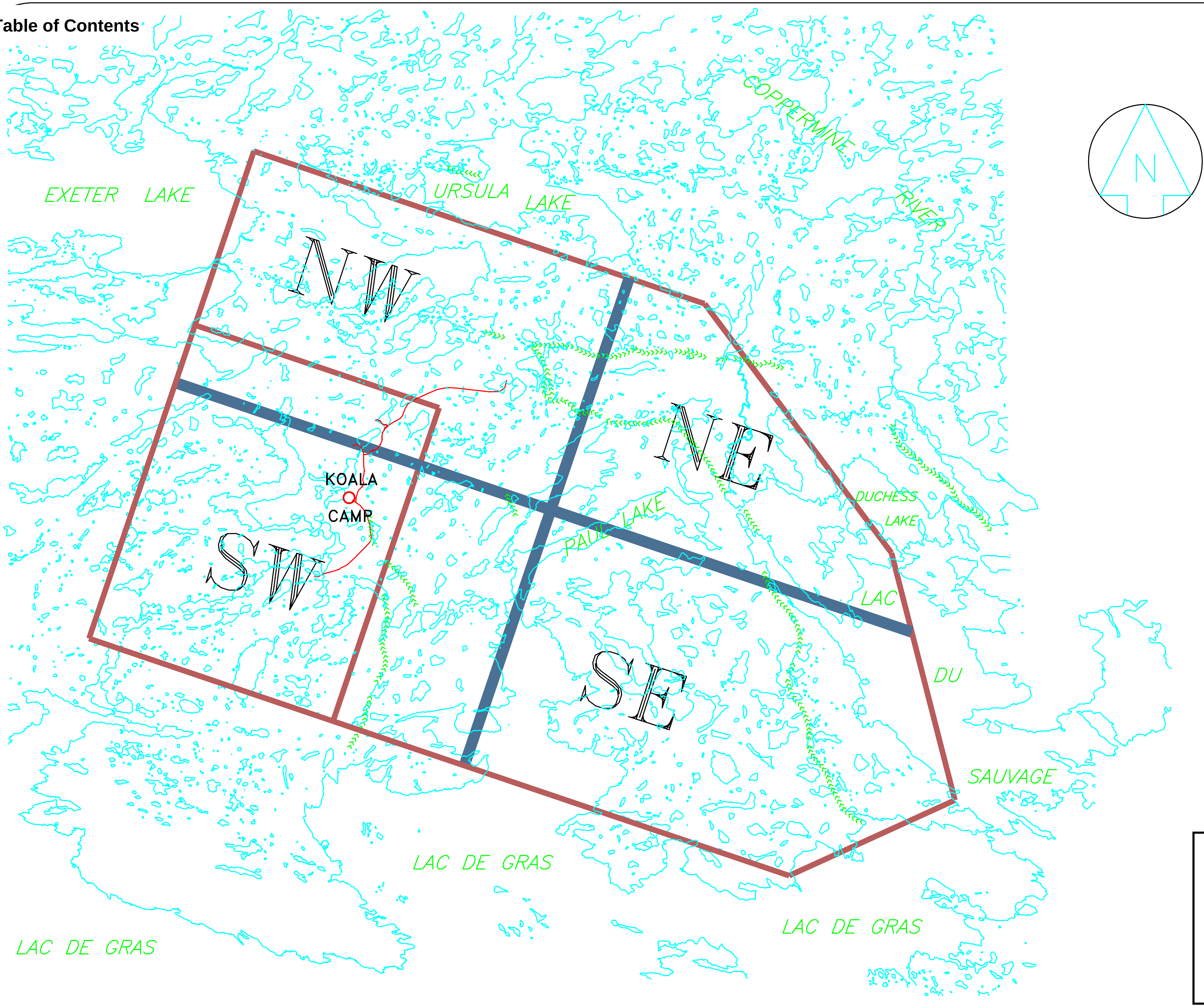

NWT DIAMONDS PROJECT

Figure 3.3-9
Caribou Distribution Quadrants in Wildlife Study Area, 1994

four quadrants. Incidental observations were incorporated with survey results when analyzing the four quadrants separately.

A total of 5,700 caribou were observed during 1994. This may be an underestimate of the caribou that existed within the wildlife study area. There appeared to be three distinct movement peaks, spring migration (early May), post-calving (mid-July to late August) and fall migration (late September to mid-October) (Figure 3.3-10). The earliest date a caribou was observed was March 3. The spring survey on May 2 and 3, 1994, documented a total of 1,330 caribou.

Most caribou (4,579) were observed in the east quadrant and 1,121 were observed in the west quadrant (Figure 3.3-11). This is, in part, a reflection of the importance of the Lac du Sauvage-Lac de Gras crossing during the spring and fall migrations (Figure 3.3-12). The presence of extensive trails supports this as a traditional crossing area.

The largest numbers of caribou during the 1994 studies (herds of 100 to 1,500) crossed Lac de Gras during spring and fall migration. The spring migration may be more spread out than the fall and of shorter duration; however, more than one year's data are necessary to substantiate these patterns of movement. Survey coverage of the wildlife study area was incomplete during spring.

Migration along the north shore of Lac de Gras during spring and fall is evident on a north-south gradient (Figure 3.3-13). Caribou predominantly used the northwest quadrant of the wildlife study area, primarily during post-calving (Figure 3.3-14). Caribou were seen in the southwest section primarily during the last half of July and in the southeast section during fall migration (Figure 3.3-15).

During migrations, the movement of caribou through the Lac de Gras area was rapid. It was common to see herds of more than 100 one day and none the next, or a herd in the morning but gone by the afternoon. Most of the fall migration in1994 was completed by the middle of October. A total of 908 caribou were sighted on October 7, 42 on October 15 and none on October 24.

Post-calving aggregations of caribou grazed in the Lac de Gras area during mid-July to early August. Groups of less than five caribou were reported in late May and June, but herds of 200 or more were observed after July 14, 1994. The most caribou observed in a single day's survey during this period was 1,199 on July 28. It is possible that 1994 was an atypical summer. The season throughout the Southern Arctic ecozone was, in general, drier than normal, resulting in decreased insect harassment. This may have encouraged caribou to disperse and spend more time grazing. Low numbers of caribou, with survey totals of less than 35, frequented the wildlife study area during late summer (August and early September).

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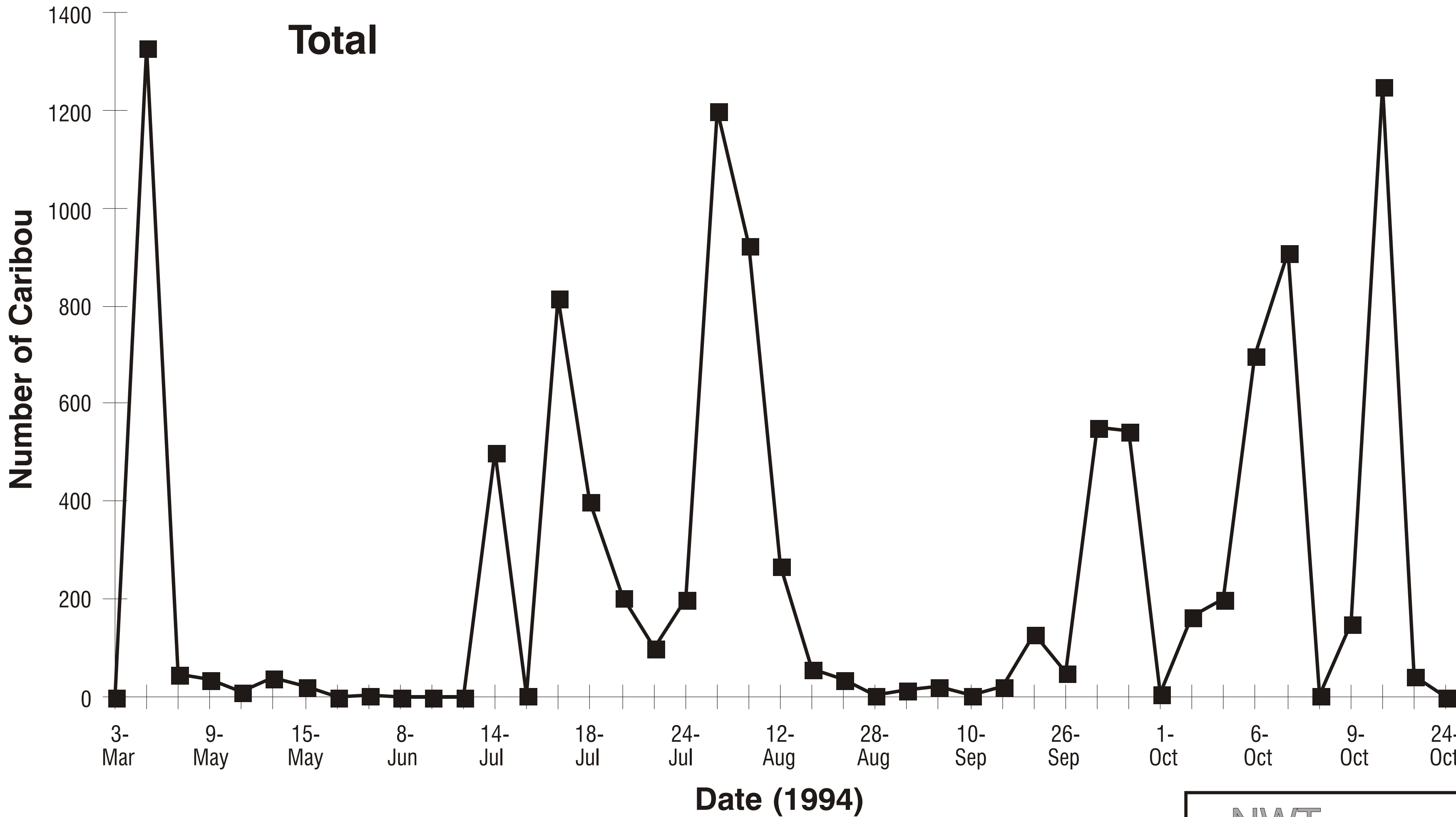
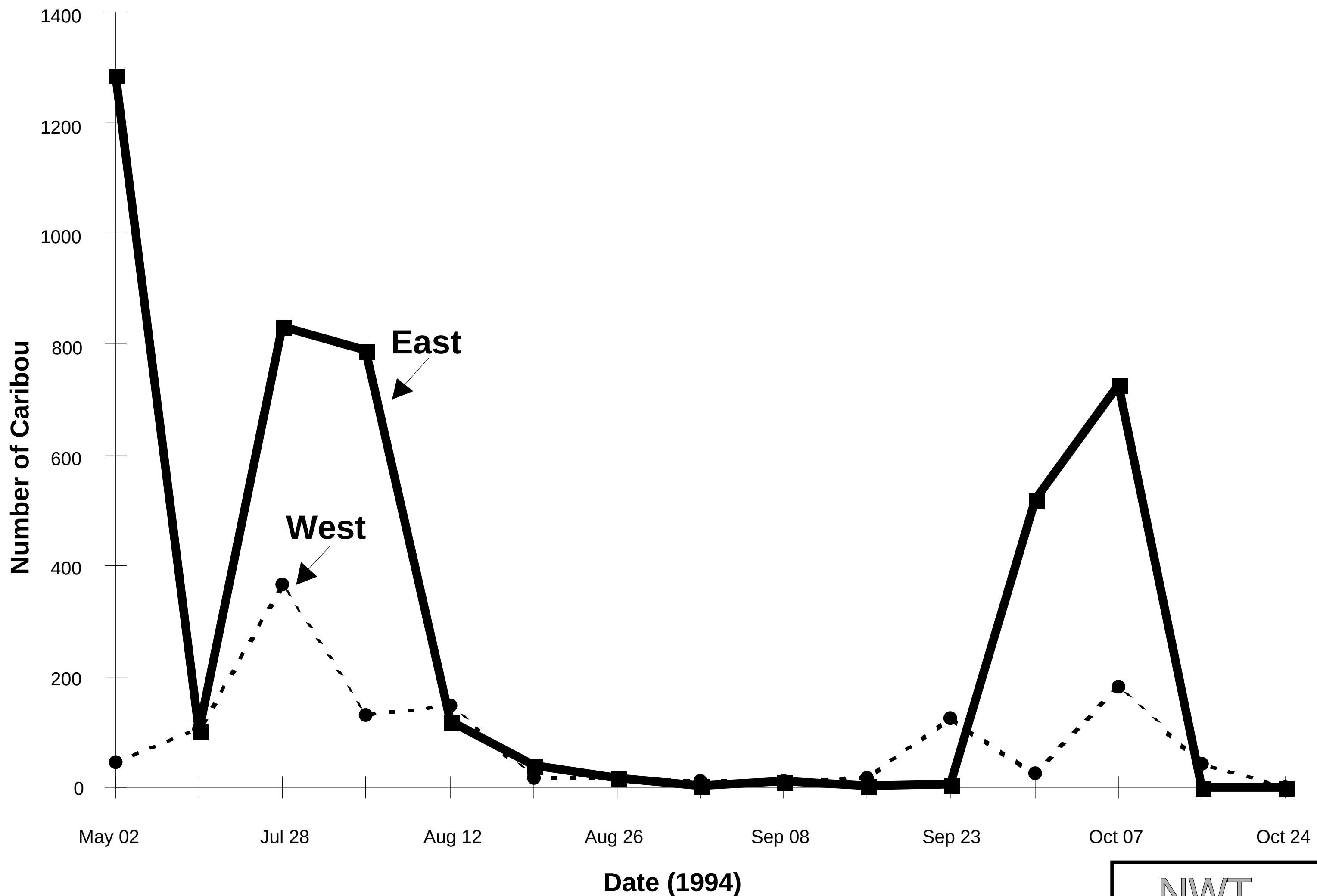


NWT DIAMONDS PROJECT

Figure 3.3-10
Number of Caribou Surveyed in Lac de Gras Area, 1994

Source: Rescan, 1994



NWT DIAMONDS PROJECT

Figure 3.3-11
Number of Caribou Surveyed in East and West Quadrants

Source: Rescan, 1994

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Source: Rescan

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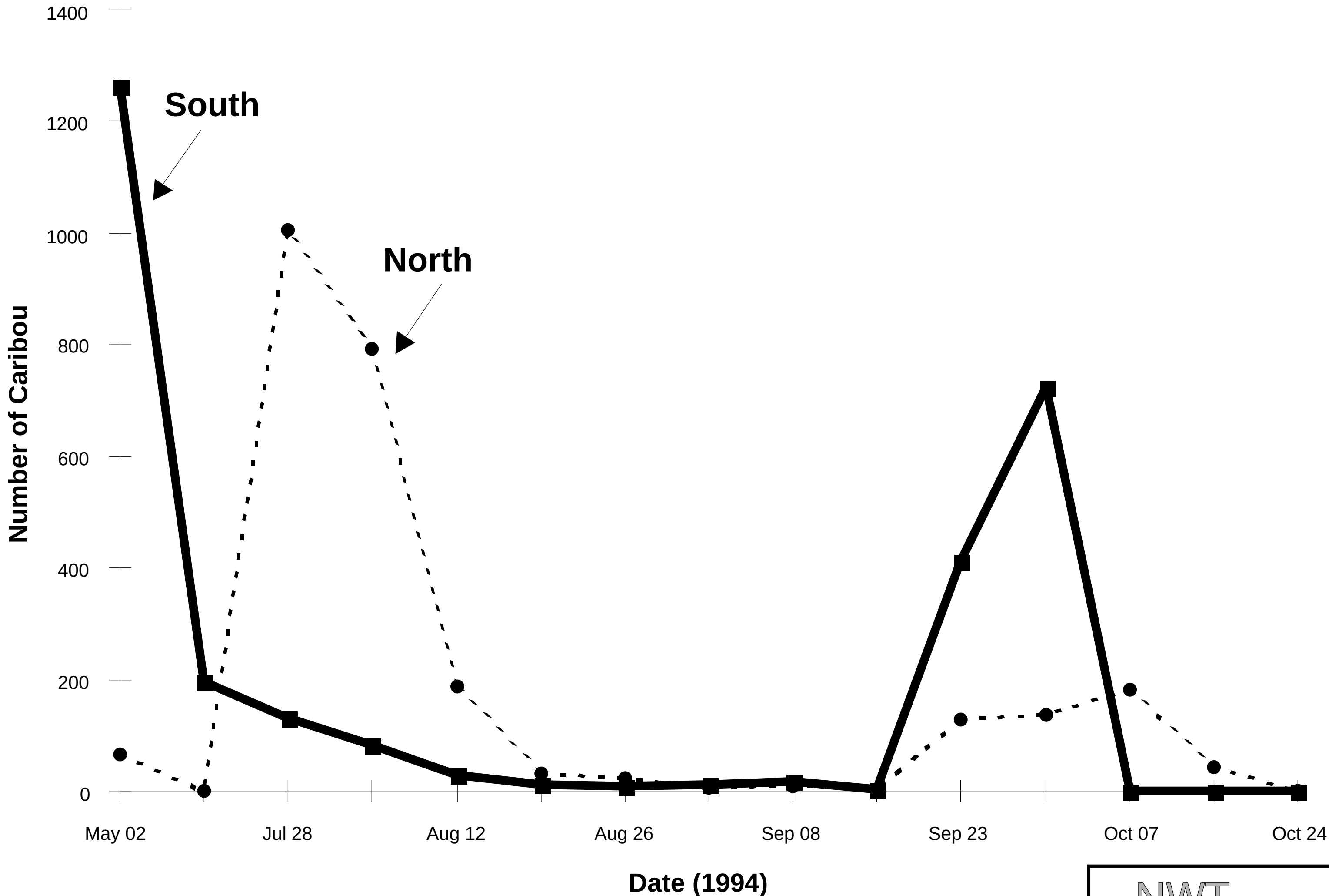
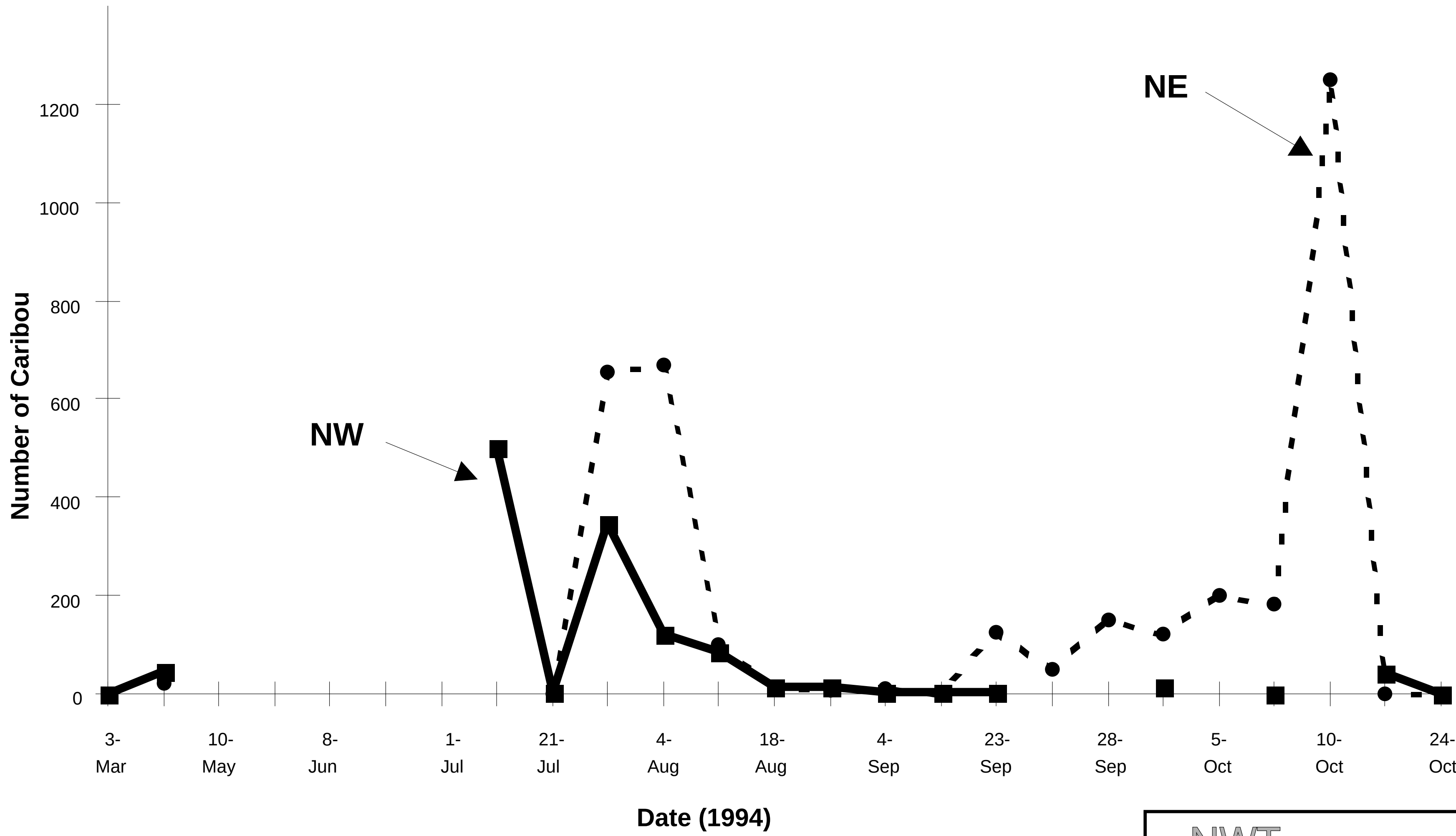


NWT DIAMONDS PROJECT

Figure 3.3-13
Number of Caribou Surveyed in North and South Quadrants

Source: Rescan, 1994



NWT DIAMONDS PROJECT

Figure 3.3-14
Number of Caribou Surveyed in NW and NE Quadrants

Source: Rescan, 1994

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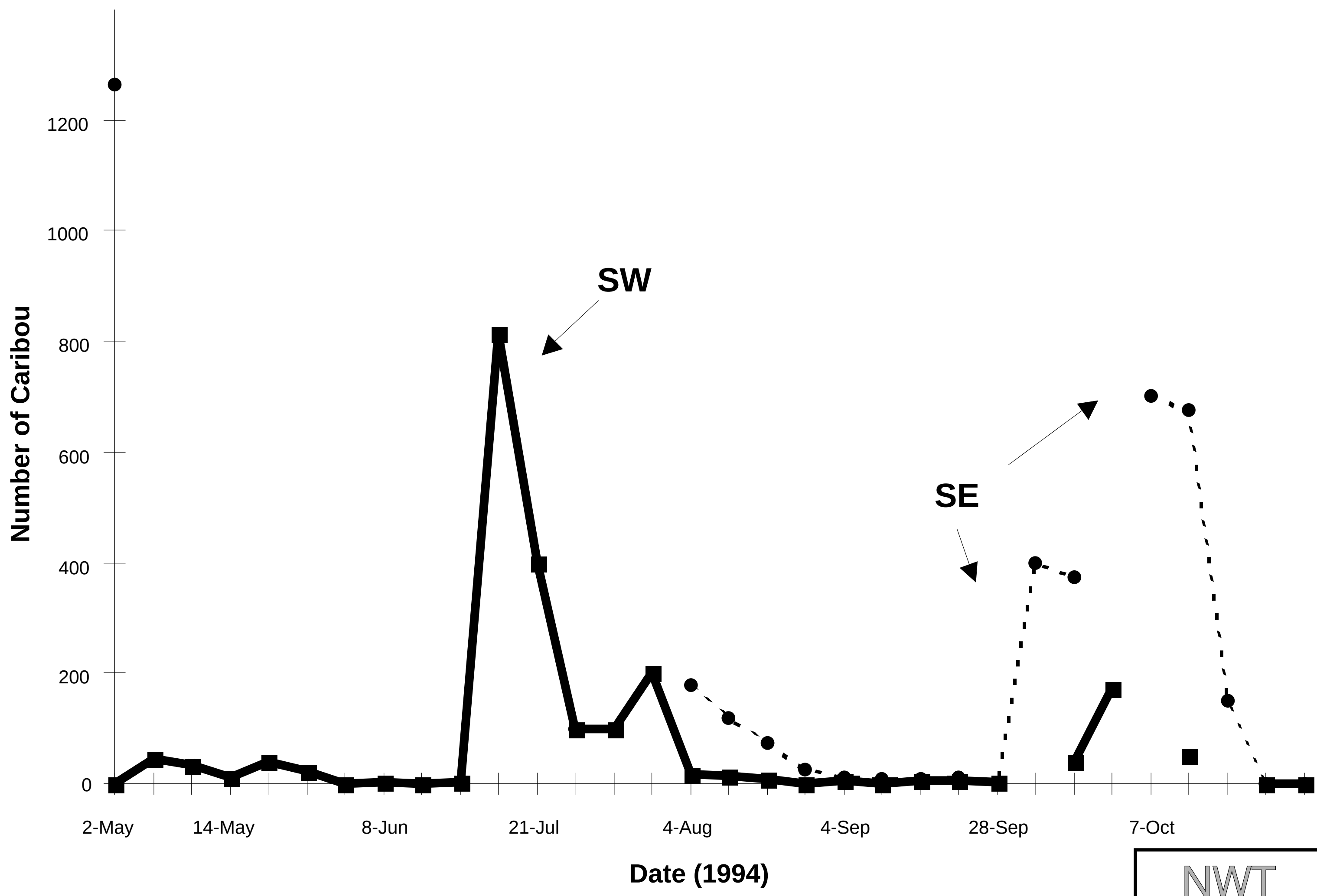

NWT DIAMONDS PROJECT

Figure 3.3-15
Number of Caribou Surveyed
in SW and SE Quadrants

Source: Rescan, 1994

3.3.2.5 Access Roads

Caribou were present in the vicinity of existing exploration roads during the summer. However, the only road that intersects migratory habitat is the proposed Misery haul road. This road will follow the migration corridor along the north shore of Lac de Gras for approximately 9 km. Its termination is 6 km from the Lac du Sauvage-Lac de Gras crossing and less than 1 km from the Lac du Sauvage esker. Although the 5 km wide corridor comprises only 10% of the overall wildlife survey area, more than 10% of the caribou were found within it. In spring, 94% of caribou within the wildlife survey area were observed within the proposed road corridor (Table 3.3-1). During both spring and fall migrations, most caribou were observed within km 20 to 30, adjacent to the Lac du Sauvage esker (Table 3.3-1).

Table 3.3-1
Caribou Observed within a Five Kilometre Wide Corridor of the Proposed Misery Haul Road, 1994

	Number of Caribou Observed						
Date	Koala to Misery Segment (Km 0 = Koala Camp)						% of Wildlife Study Area (No.)
	0-5	**5-10**	**10-15**	**15-20**	**20-25**	**25-30**	**30 km**
May 2-3	0	0	150	100	600	400	94 (1250)
Jul 21	0	0	0	0	0	100	49 (100)
Jul 28	2	11	8	0	111	11	12 (143)
Aug 4	0	0	6	0	0	4	10 (10)
Aug 12	2	1	20	0	1	26	18 (50)
Aug 18	0	2	3	2	2	1	17 (10)
Aug 26	5	2	0	0	1	1	26 (9)
Sep 4	0	0	0	4	1	0	36 (5)
Sep 8	0	4	0	2	0	0	30 (6)
Sep 17	0	0	2	0	0	0	10 (2)
Sep 23	0	0	0	0	0	0	0
Sep 28						*350*[1]	
Sep 30	0	0	0	0	3	200	55 (203)
Oct 6						*700*	
Oct 7	0	0	0	0	55	210	29 (265)
Oct 9						*150*	
Oct 15	0	0	0	0	0	0	0
Oct 22	0	0	0	0	0	0	0
Total[2]	**9**	**20**	**189**	**108**	**774**	**953**	

1: Caribou sightings in italics indicate incidental observations, i.e., not during scheduled surveys.
2: Not including incidental observations.

Few caribou were present in the proposed road corridor after spring migration. Only at the end of July were caribou seen in some numbers (Table 3.3-1). Low numbers of caribou (14 and less) were observed in the corridor during late summer, August and early September, and none in late October (Table 3.3-1). Few caribou were in the Lac de Gras wildlife survey area at this time.

Of the total caribou observed (5,700), only 760, or 13%, were identified by sex. Of those identified, the majority, 61%, were cows (466), 21% were bulls (160) and 18% were calves (134). The preponderance of cows can be attributed to the ease of identifying sex in the small post-calving aggregations, especially during August.

3.3.2.6 Future Plans

Caribou field studies are continuing during 1995, particularly during spring and fall migrations. In the future, caribou surveys will be conducted as part of the ongoing wildlife monitoring program. Variation in movement patterns and use of habitats will be monitored. In conjunction with knowledge gained from the Traditional Knowledge Study, this information should allow the Proponent to adequately manage impacts on this important resource.

3.3.3 Grizzly Bears

The last populations of grizzly bears (*Urus arctos*) in the world in what is essentially pristine wilderness are found within British Columbia, Yukon, Northwest Territories and Alaska. Due to potential impacts of mortality and habitat displacement on grizzly bears, they are considered by biologists to be the most sensitive species within the Lac de Gras area. As such, they are considered a valued ecosystem component.

The objectives of the 1994 field studies were to document grizzly bear sightings and distribution and to obtain preliminary diet information. Grizzly bears were observed on 14 occasions within the wildlife study area during 1994. Some of these may have been the same bears. No females with young were observed. Twelve scats were collected and analyzed, indicating that caribou was the most frequent food item. Other animal foods included arctic ground squirrel, ptarmigan and hare (snowshoe hare *Lepus americanus* or arctic hare *L. arcticus*). Ground squirrels appeared to be an important food item in the fall. Ten confirmed bear dens and ten possible bear dens were located.

3.3.3.1 Previous Research and Traditional Knowledge

Grizzly bears belong to the family Carnivora. They have the digestive system of a carnivore but they are better described as successful omnivores. In some areas, and at some times during the year, their diets may be almost entirely herbivorous. Grizzly bears switch food types depending on the area and on the season according to the abundance of such foods. They prefer high-energy, protein-rich and easily digestible foods. The activities and diets of some bears as they forage in late spring and early summer follow the phenologies of various plant species. Animal matter is an important food, if and when available. In the Southern Arctic Ecozone, animal protein is available in the form of barren-ground caribou and ground squirrels. If permitted, grizzly bears will feed on garbage and other human foods, which may result in conflict with humans.

Research on grizzly bears has been conducted in the Northwest Territories, in arctic coastal habitats and in the Mackenzie and Richardson mountains. There have been no studies on the barren-ground grizzlies of the Southern Arctic. Grizzly bears within this Ecozone are probably at the low end of the continuum of densities in North America. Habitat productivity for grizzly bears is low because of slow growing vegetation, low diversity of prey species and limited availability of caribou carrion.

Grizzly bear populations grow slowly. Litter sizes are small, ranging from one to three. Mean litter sizes range from 1.6 to 2.5 young and the interval between litters ranges from 2.0 to 4.3 years (Banci 1990). The mean age of first parturition ranges from five to as old as eight years, depending on the quality and quantity of food available (LeFranc *et al.* 1987). The interval between births ranges from two to five years. There does not appear to be an upper limit as to when reproduction ceases. Females as old as 24 and 25 years have been observed with young.

Females that have access to predictable and high value foods such as meat and berries attain a greater adult size, mature earlier and have larger litters than those with access only to foods with low nutritional value such as roots (Nagy and Russell 1978; Knight *et al.* 1986). For example, coastal grizzlies with access to spawning salmon have large litters, earlier sexual maturity dates and heavier female weights (Bunnell and Tait 1981) than bears without access to salmon. The Southern Arctic Ecozone is low in abundance and diversity of bear foods, with protein sources being relatively rare and present primarily when caribou and, secondarily, ground squirrels are available.

Grizzly bears require dens secure from disturbance in which to over-winter and reproduce. Dens are rarely found singly but are concentrated in areas with suitable environmental conditions (LeFranc *et al.* 1987). These areas are thought to result from individual fidelity to dens over several years and the population distribution in any particular year. The availability of dens can be a factor limiting reproductive success, especially in habitats where dens are not easily excavated (Macey 1979).

Characteristics of grizzly bear dens in the Northwest Territories have been described for arctic coastal habitats, Richards Island and the Tuktoyaktuk Peninsula (Harding 1976; Nagy *et al*. 1977; Nagy *et al*. 1983), and near Coppermine (Gunn 1991). More recently, characteristics of carnivore dens in eskers within the Southern Arctic Ecozone, including the Lac de Gras area, were quantified (Meuller 1995). Characteristics included particle size, slope, vegetation, cover, biomass and carbon, water and nitrogen content.

Grizzly bears occupy an important place in both Inuit and Dene mythology. As a subsistence item, however, they did not play a large role. The importance of this species as food to the Dene and Metis is illustrated in Figure 3.3-16. Nonetheless, some Aboriginal people and organizations, such as the Kitikmeot Hunters and Trappers Association (Ron Tologanak, Coppermine), remain very concerned about the conservation of grizzly bears. Many Aboriginal people possess knowledge about grizzly bears in the context of their predation on caribou.

3.3.3.2 Methods

Field work during 1994 consisted of documenting grizzly bear sightings and use of eskers. Dens were located during surveys of eskers and by searching off-esker during other field activities. UTM coordinates, slope aspect and position of dens were noted.

Scats were collected when found and subsequently frozen. They were then oven-dried and food items were identified. Results are presented as percent occurrence by volume.

3.3.3.3 Bear and Human Safety

Measures to prevent negative bear encounters at the exploration camp and in the field have been implemented. The exploration camp was surrounded by an electric fence, which was continuously “on” except during winter, when bears were inactive. Attractions at the exploration camp were eliminated. All kitchen and food wastes were incinerated on site. Kitchen water and sewage were treated and discharged with tailings.

Education is important in preventing conflicts and increasing the comfort level of persons who work and live in bear country. All residents of the exploration camp were required to attend bear safety lectures. An information booth was established at the camp with information on bears and other wildlife species to encourage workers and visitors to learn about bear safety. Firearms were restricted to few personnel for safety purposes only. Bear deterrents such as

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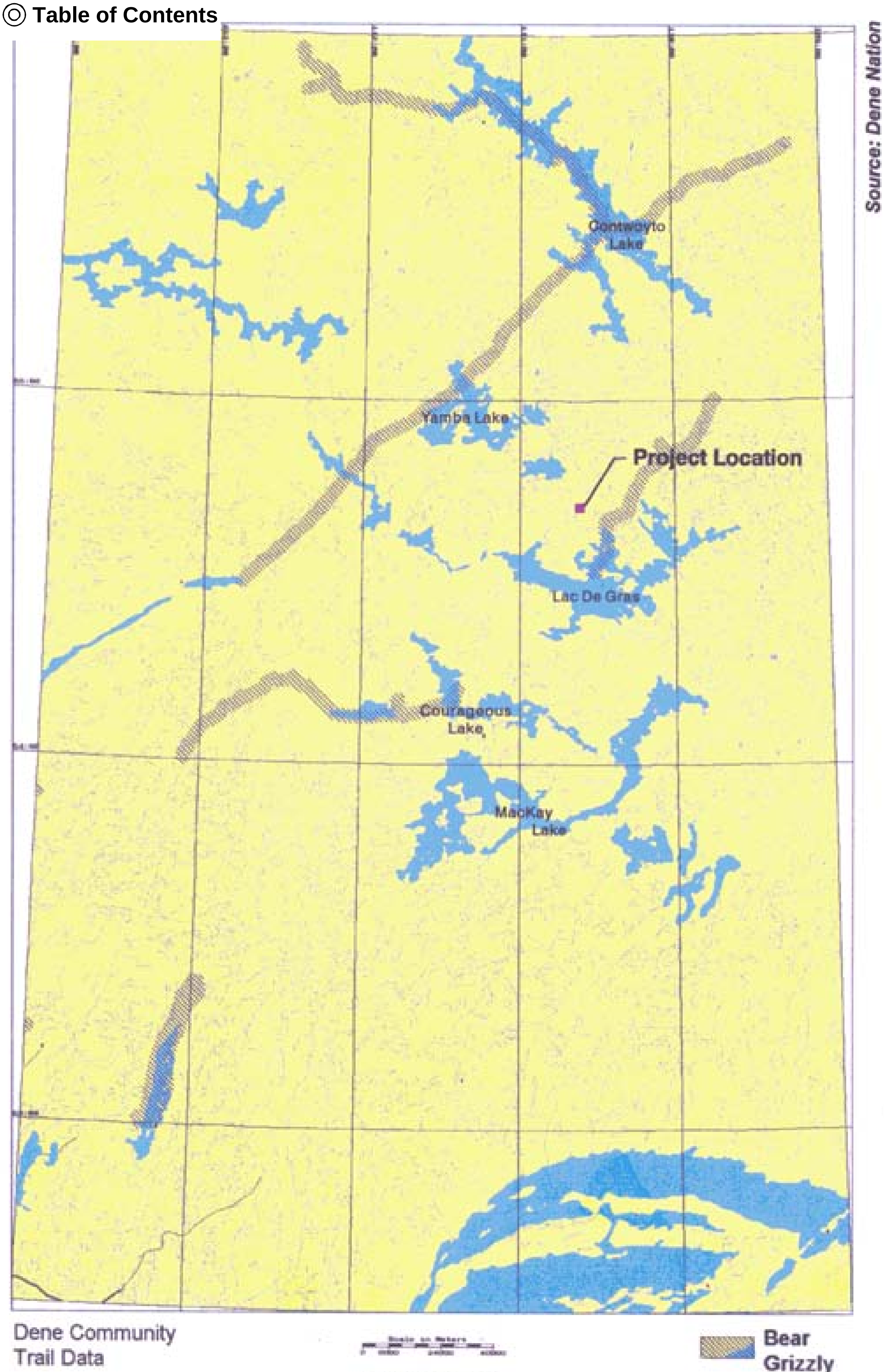

Dene Community Trail Data

Figure 3.3-16

bangers and capsicum spray were available to persons working in the field who were instructed on their limitations.

3.3.3.4 Observations

The bear observation period for the 1994 season was August 9 to the beginning of the hibernation period in October. Confirmed observations of grizzly bears consisted of sightings (ten sightings of 11 bears) or sign, such as tracks or scats (three occurrences). Most bears were not identified to specific sex or age and one observation was of a mated pair (Table 3.3-2). No females with young were observed. Only fresh sign was used as evidence of a bear sighting.

Table 3.3-2
Grizzly Bears Observed at Lac de Gras, 1994

Date	Age - Sex	UTM Easting[1]	UTM Northing[1]	General Location
Aug 9	Adult Male	512400	7169800	Martine Lake
Aug 12	Adult	539170	7165100	2 km west of Lac du Sauvage
Aug 12	Adult Male, Female	536700	7164600	North of Pt. de Misère
Aug 12	Adult Male	535100	7163670	North of Pt. de Misère
Aug 15	Unknown	518540	7177700	1 km east of Panda Lake
Aug 16	Unknown	519100	7176900	Northwest of Panda Lake
Aug 30	Unknown	530830	7186000	Ursula Lake - east side
Aug 30	Unknown	532680	7164650	West of Lac du Sauvage Esker
Aug 31	Unknown	508020	7164850	Slipper Lake, west bay
Sep 3	Unknown	517600	7180450	South of Vulture Lake
Sep 11	Adult Male	535980	7175630	West of Duchess Lake
Sep 14	Adult Male	535650	7180630	South of Ursula Esker
Oct 10	Unknown	532475	7181065	South of Ursula Esker

1: UTM grid zone designation is 12.

These data do not indicate densities, as some of these may have been the same bear observed more than once and some bears may not have been observed. Of the ten direct sightings, four were obtained during caribou surveys, five during other helicopter work, and one from the ground. Of the fresh signs, one observation was of scats at a recent caribou kill and two were fresh tracks.

Three of the 13 observations were near the exploration camp. One adult male was observed at Martine Lake and two others (unknown age/sex) near Panda Lake. There was no evidence of extensive feeding activity or of vegetation communities important to bears at or adjacent to the exploration camp.

3.3.3.5 Food Habits

The diets of grizzly bears in the area are based on scats collected over a brief period. However, they do indicate some of the foods that grizzlies consumed during the fall. Thirteen scats representing eight individual bears were found. Four scats were collected at two fresh caribou kill sites. Others were found at locations where bears were observed and by tracking bears in the snow.

Caribou was the most frequent food item found in nine of the 13 scats (Table 3.3-3). A majority, if not all, of the caribou in the diet was likely scavenged from wolf kills. Other animal foods included arctic ground squirrel, ptarmigan and hare (snowshoe hare or arctic hare). Ground squirrels appeared to be an important food item in the fall. There was much evidence of bears digging up ground squirrel burrows on eskers during September and October.

Table 3.3-3
Food Item Occurrence in Grizzly Bear Scats
Collected August 31 to October 13 1994[1]

	% Occurrence				Overall Average (%)
Food Item	**Range**	**Average**	**+/- sd**	**No. of Scats**	**(in 13 scats)**
Animal					
Caribou	40 to 100	73	22	9	58
Arctic Ground Squirrel	8 to 100	45	38	5	17
Ptarmigan	1 to 5	3	3	2	Trace
Hare[2]		Trace		1	Trace
Vegetation					
Carex spp.	Trace to 100	18	40	11	15
Vaccinium vitis-idaea	Trace to 2	Trace	1	6	Trace
Empetrum nigrum	5 to 20	12	7	5	4
Ledum decumbens	Trace	Trace		4	Trace
Vaccinium uliginosum	Trace	Trace		2	Trace
Arctostaphylos alpina	Trace	Trace		2	Trace
Betula glandulosa	Trace	Trace		2	Trace
Hedysarum sp.	Trace	Trace		2	Trace
Shepherdia canadensis	1 to 15	8	10	2	1
Lycopodium sp.		1		1	Trace

1: Thirteen scat collections from eight individual bears. Trace is <1% of occurrence.
2: Arctic hare or snowshoe hare.

Sedges (*Carex* spp.) were the most frequent vegetation species consumed, found in 11 of the 13 scats (Table 3.3-3). Two of the scats were comprised solely of sedges. Berries, crowberry (*Empetrum nigrum*), cranberry (*Vaccinium vitis-idaea*) and blueberry (*V. uliginosum*) were consumed as well. Two plant species of interest found in scats were potato root (*Hedysarum* sp.) and soopolallie (*Shepherdia canadensis*). Both species, in particular potato root, are important grizzly bear foods. However, neither plant was observed during the limited amount of habitat work conducted in 1994, nor was there any evidence of bears feeding on vegetation. Habitat mapping to be conducted during the summer of 1995 will document the occurrence of these communities and their use by bears.

3.3.3.6 Dens

A den was classed as "confirmed" if it appeared to have been used the previous winter and as "possible" if it was the result of bear digging activity but there was uncertainty as to whether it had actually been used by a bear the previous winter. Dens differed from bear digging activity for ground squirrels or vegetation.

Nine confirmed den locations composed of ten dens and seven possible den locations, also with ten dens were found (Table 3.3-4). Most of the dens classified as possible were shallow depressions. A grizzly may be able to use such a den due to the insulative value of snow (Meuller 1995).

One confirmed den location and three of the possible dens consisted of two excavations adjacent to each other. It is possible that one or both of these "dual" dens represents an aborted attempt to excavate a den. It is not unusual for barren-ground grizzlies to start a number of dens before finally selecting the one they use (G. MacHutchon, pers. comm. 1994). The relatively large proportion of dual dens in the possible den category (three of seven) compared to the confirmed den category (one of nine) suggests that bears at Lac de Gras initiate a number of dens that may not be where they spend the winter.

Four confirmed dens and one possible den were found on the Lac du Sauvage esker. This esker is 29.5 km in length, the longest esker within the wildlife study area. All dens had been excavated either in eskers or in mounds of glacial deposits. Other areas were searched during ground and air activities. Although they are rare (Meuller 1995), it is possible that dens exist on the tundra but it is difficult to locate dens in tundra vegetation. Two off-esker dens were found, one confirmed and the second possible, both in mounds of glacial-fluvial material. The largest den was one of these off-esker dens. Its dimensions were 2.9 m in length, 1.2 m in width and 0.43 m in height. It was associated with a smaller den 1.28 m in length and more typical of dens found on eskers.

Table 3.3-4
Grizzly Bear Den Locations and Characteristics, 1994

Number of Entrances	Aspect (°)	Position on Slope[1]	UTM Easting[2]	UTM Northing[2]	General Location
Confirmed Dens					
1	134	3	520130	7166500	Fish Lakes Esker
1	14	3	516700	7189010	Ursula Esker (West)
2	172	3	517850	7188550	Ursula Esker (West)
1	257	1	527120	7178950	Lac du Sauvage Esker
1	213	1	539750	7161930	Lac du Sauvage Esker
1	144	1	528600	7178250	Lac du Sauvage Esker
1	76	3	529500	7178070	Lac du Sauvage Esker
1	0	0	513121	7162269	Step Lakes
1	327	1	521422	7185642	Off esker, N. of Little Exeter L.
Possible Dens					
1	133	3	519360	7164890	Fish Lakes Esker
2	200	1	506697	7184642	Exeter Esker
2	146	1	510480	7183985	Exeter Esker
2	170	2	518600	7188650	Ursula Esker (West)
1	150	2	534740	7180630	South of Ursula Esker
1	147	1	535950	7173600	Lac du Sauvage Esker
1	205	1	545516	7321500	Off esker, east of Duchess L.

1: Position on slope: 1=top, 2=middle, 3=bottom, 0=top or flat.
2: UTM grid zone designation is 12.

All possible dens had southerly aspects, as did four of the confirmed dens. Two others had northerly aspects, one easterly, one westerly and one was on flat ground. Where situated on slopes, all confirmed dens were equally split between bottom or top of the slope (four each). Of the seven possible den sites, four were located on the top, one on the bottom and two in the middle. Dens were typically associated with other signs, feeding sign in the form of digging for ground squirrels, caribou kills or day beds. The presence of food may be an important factor in den selection, or it may be coincidental.

3.3.3.7 Future Plans

The low density of grizzlies made it difficult to observe bears and to locate feeding sign. The verification of the habitat map, to be conducted in 1995, will identify the location of vegetation communities important to grizzlies. However, to obtain a more complete understanding of grizzly bear habitat use, individuals need to be radio-collared and monitored. Nutrition and diet studies will be conducted in cooperation with the University of Saskatchewan and the Department of Renewable Resources. The overall objective of this study is to delineate populations and determine habitat use at a landscape level. This research is one component of a larger study, as part of the Slave Geological Province Regional Study Plan. The Proponent has committed funds to support this research.

Grizzly bears have been collared with dual satellite and VHF transmitters. VHF transmitters will permit intensive monitoring to determine habitat use and the identification of important seasonal habitats at a larger map scale. Other plans for 1995 include the continuation of the field work initiated in 1994, monitoring of sightings, dens and habitat use.

While the documentation of traditional ecological knowledge relating to grizzly bear behaviour and habitat may lessen the need to carry out satellite and VHF tracking studies, the latter research may still be required to effectively manage this valued ecosystem component. If so, a cross-cultural communication program will be conducted with the aim of educating both Aboriginal people and scientists and involving Aboriginal people and knowledge in monitoring plans.

3.3.4 Furbearers

The furbearers found in the wildlife study area are foxes, wolves, wolverine and ermine (*Mustela erminia*). Foxes and wolves belong to the canid family and wolverine and ermine to the mustelid family. All four species are carnivores. The canids are hunters, taking prey ranging in size from shrews to caribou. Among this family the wolf is the primary predator of barren-ground caribou. Two fox species, arctic and red fox, are common in the area. Both are effective predators and can have significant impacts on populations of small mammals and nesting waterfowl. Wolverine are also carnivores but are primarily scavengers. They rely on the kills of the more successful hunters, the wolves. Ermine are small predators that concentrate on small mammals such as mice and voles.

The term "furbearer" is a legal designation, meaning that these animals may be trapped for their pelts. Foxes, wolves and wolverine are important species in the fur harvest, especially above treeline because of the lack of other furbearers such as marten (*Martes americana*), beaver (*Castor canadensis*), mink (*Mustela vison*) and lynx (*Lynx canadensis*). Ermine pelts are low in value compared to other species and do not figure prominently in the harvest.

Lac de Gras is remote, above treeline and with low diversity and abundance of furbearers. Foxes and wolverine are present year-round while wolves are only present when caribou are present. Ermine are also found year-round but are difficult to see and inventory without intrusive methods, i.e., trapping. Trapping of any of these species does not take place currently at Lac de Gras. It is unlikely that furbearers living at Lac de Gras may be trapped by communities elsewhere, with the possible exception of wolves and perhaps wolverines. Only these two species have extensive movements that could bring them into contact with trappers and hunters.

Furbearers, especially wolves and wolverines, are considered a valued ecosystem component because of their role in the food chain, their importance in the fur market and their high public profile. The national designation of wolverine as vulnerable also makes it a species of concern.

The objectives of studies during 1994 were to document the presence of furbearers, to describe preliminary diets and to identify denning locations for foxes and wolves. Arctic foxes were common, much more than red foxes. An active fox den adjacent to the airstrip at Koala Camp resulted in frequent interactions between people and the foxes.

Within the wildlife study area, there were 17 observations of wolves adjacent to existing roads, the camp and the airstrip, and 17 observations outside of this area. Thirteen sightings of wolverine were recorded. Nine fox dens and six wolf dens were identified. Caribou was a prominent prey item in scats of all carnivores. No information on habitat use or food habits was obtained for ermine in 1994.

3.3.4.1 Previous Research and Traditional Knowledge

The following discussion summarizes previous research and traditional knowledge pertaining to foxes, wolves and wolverine.

Foxes

Arctic foxes are circumpolar in distribution, while the red fox is the most widely distributed carnivore in the world (Voight 1986). The southern distribution limit of the arctic fox is generally described as the northern edge of the treeline. Although both species have been studied frequently throughout their range, the understanding of the nature of the relationship between red foxes and arctic foxes in the Southern Arctic Ecozone is limited.

Foxes are solitary but form temporary social groups during the breeding season. The basic social unit is an adult male and female and their pups. One or two additional adults may be associated with the family group. Pairs seek den sites beginning in February and March and most pairs are established at dens no later than early May (Garrott and Eberhardt 1987). Family groups focus much of their activity around dens until midsummer when the pups begin to wander extensively. The juvenile foxes disperse in the fall.

During the summer, foxes prey primarily on birds and small mammals. Lemmings are the predominant small mammal eaten by arctic foxes, and voles may also be consumed where and when they are numerous (Garrott and Eberhardt 1987). Fluctuations in numbers of arctic foxes may be tied to lemming cycles (MacPherson 1969) but the nature of this relationship is poorly understood. However, as Aboriginal people possess knowledge relative to understanding fox cycles, they may provide insight into this relationship. Other fox prey includes ground squirrels, insects, snails, snowshoe and arctic hares, fish, caribou and berries. Little is known about their winter ecology except that arctic foxes are solitary and highly mobile.

Foxes require suitable substrate to establish their dens. In the Southern Arctic Ecozone, foxes den in eskers and other accumulations of glacial-fluvial materials. According to Dogrib elders, a high concentration of fox and wolf denning sites are found on glacial features (Figure 2.1-2) between the north end of MacKay Lake and the southeast end of Lac de Gras (Appendix I-A1:Map Four).

Locations where Dene/Metis and Inuit traditionally set trap lines for fox in the region are provided in Figures 1.2-5 and 1.2-9, respectively. While Inuit tended to trap fox north and east of Lac de Gras, Dene/Metis usually set fox traps south of Trap Lake around Ek'ati tata. Although fox trapping no longer is undertaken in Ek'ati tata, some elder Dene might consider returning to the area if fox fur prices rise (Louis Wion, elder, Snare Lakes).

Foxes can occupy dens for many years because denning sites are rare and localized. MacPherson (1969) calculated that dens in the Canadian Arctic could be used for several centuries before the burrow system collapsed. As a result of many years of occupancy and gradual expansion, a den can evolve into a large complex system covering several hundred square metres and containing 20 to 80 burrow entrances (MacPherson 1969). Thus, the complexity of the burrow can be an indication of its length of occupancy. Foxes can use more than one den during a season. Family groups may abandon a den site and move to another several kilometres away or may simultaneously occupy several dens.

Wolves

Wolves are widely distributed throughout Canada and the Northwest Territories. Wolves inhabiting migratory caribou ranges prey primarily on caribou (Williams 1990), and recent research has focused on the importance of caribou to the wolf diet and on the geographic distribution of dens (Heard and Williams 1992). There are an estimated 1,400 to 3,000 wolves on the Bathurst range; however, their exact population status is unknown (GNWT 1988). Most wolves on the Bathurst caribou range do not appear to be territorial throughout the year but move as required to remain with the herd (Heard and Williams 1992). During summer, the density of denning wolves appears to be greatest near the treeline (Heard and Williams 1992).

Wolf pups are born in dens in late May and early June and do not move with the pack until late August. Treeline dens may persist longer and be reused more frequently than tundra dens (Heard and Williams 1992). Of 63 wolf dens found on the Bathurst caribou range, 26 were on tundra, 28 in the treeline transition area and nine in the forest (Heard and Williams 1992).

Dogrib elder knowledge indicates a high concentration of wolf denning sites north of Lac de Gras (Appendix I-A1:Map Four). However, traditional Dene use of this area for wolf does not appear to be any more or less intensive than anywhere else on the barren lands (Figure 3.3-17). Inuit traditionally hunted wolf north of Lac de Gras (Figures 1.2-10 and 1.2-11), especially when they wintered over at Contwoyto Lake. However, with the recent increase in the price of wolf, Inuit hunters from Coppermine are beginning to travel greater distances in search of this species.

"For the Lupin mine site anyway, I don't think (mining) affects (wildlife) very much. The caribou are still going around there. The wolves and wolverine are still there. Sometimes the dump being there is a good thing for the hunters, when they go up from here (Coppermine) there's wolves and wolverines around" (Jimmy Ross Miyok, Coppermine).

The Lupin mine dumps has apparently attracted rabbits, a favourite food of these carnivores:

"There's hundreds of rabbits, Arctic Hare, mating in Lupin and most of them are living in the dumps now. Rabbits are supposed to be white animals, but they're black most of the time" (Aime Ahegone, elder, Coppermine).

Given the experience at Lupin and the high density of wolf denning sites north of Lac de Gras, an increase in encounters between humans and wolves might be expected.

Wolverine

Although wolverine range throughout most of western and northern Canada, little is known about this elusive species. Only four North American field studies on wolverine have been completed: two in Alaska (Gardner 1985, Magoun 1985) and one each in the Yukon (Banci 1987) and Montana (Hornocker and Hash 1981). Carcass analyses within the Northwest Territories are in progress (GNWT 1992 to present). The Department of Renewable Resources has radio-collared a small number of wolverine in the Southern Arctic Ecozone, but technical difficulties have prohibited obtaining information on movements or home range use.

Wolverine live at low densities even under the most optimal conditions (Banci 1994). Reproductive rates are low and sexual maturity delayed, in comparison with other mammalian carnivores. Wolverine are scavengers and hunters of birds and small mammals, relying on a diversity of foods to offset the uncertainty of availability in the harsh northern environment. There appears to be a correlation

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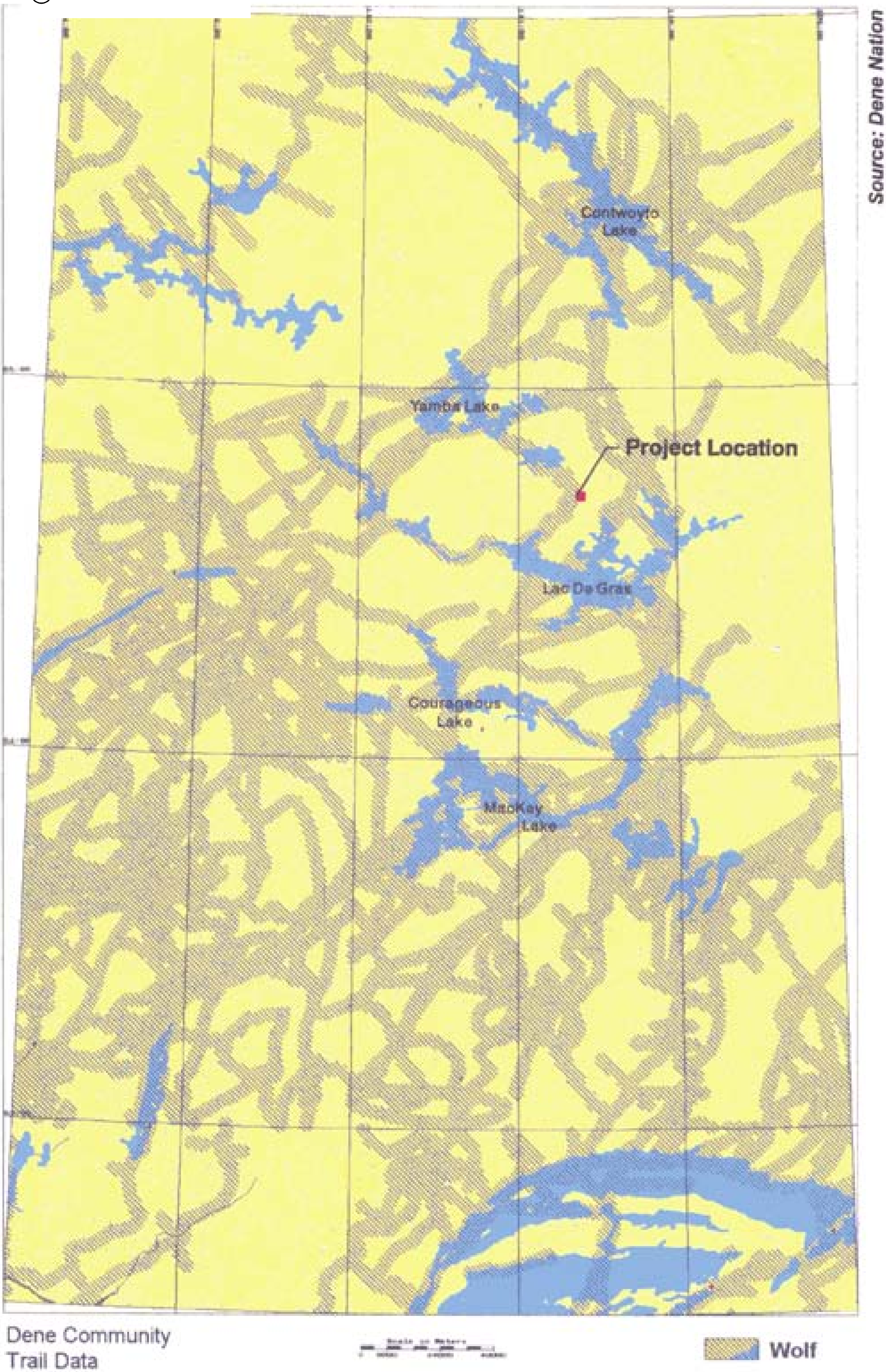

Dene Community Trail Data

Figure 3.3-17

between wolverine, large ungulate populations and the presence of more successful hunter-carnivores such as wolves.

Within its geographic range, wolverine occupy a variety of habitats. However, a general trait of areas occupied by wolverine is their remoteness from humans and intensive development. Within wilderness areas, some wolverine learn to take advantage of human foods (feeding in garbage dumps, breaking into cabins and caches, and following traplines, removing animals that have been captured).

Wolverine are an important furbearer for local communities. They are harvested by more than 30 communities representing all regions of Northwest Territories (Lee 1994). Wolverine fur is renowned for its frost-resistant qualities and is highly sought for use as trim on parkas.

Habitat Use

The habitat of large carnivores is generally non-specific and a function of the habitat used by their prey. However, foxes and wolves establish natal dens in eskers and in other deposits of glacio-fluvial material. Eskers are considered a special habitat because of their importance to wildlife and their relative rarity in the landscape (Section 3.3.6). These species may be especially sensitive to disturbance during the denning period. It is possible that wolverine use eskers for dens; however, all dens described to date consist of extensive tunnels burrowed under the snow (Banci 1994).

3.3.4.2 Methods

Field work during 1994 consisted of documenting sightings and den locations. A second source of information was incidental observations recorded by Rescan biological staff, helicopter pilots and residents of the NWT Diamonds Project exploration camp during all field activities. Due to the number of people and the extent of their activities, incidental observations became a supplemental source of information to the planned surveys.

Confirmed observations of foxes and wolves consisted of sightings or sign, tracks or feeding sign. Scats were collected and subsequently frozen. Scats were oven-dried and food items identified. Results are presented as percent occurrence by volume. Fox and wolf dens were found during esker surveys and by searching off-esker during other field activities. Universal Transverse Mercator (UTM) coordinates, slope aspect and position of dens were noted.

Foxes

Arctic foxes were common in the wildlife study area. They were observed in all habitats and in all areas. Fewer red foxes were observed. Both species became quickly habituated to the NWT Diamonds Project exploration camp and human activity. One arctic fox family used a den excavated in a mound of glacio-fluvial material adjacent to the airstrip. This den had a minimum of 15 entrances, the most of any fox den found. This den appeared to have been used for a number of years, although it did not approach the complexity of fox dens described by MacPherson (1969). Of all wildlife species, foxes had the most frequent interactions with people, in part because of the proximity of the active den.

Not including the airstrip den, nine fox dens in four eskers were identified (Table 3.3-5). Two of these were red fox dens, the others arctic fox. All of the dens had a southerly aspect, suggesting that aspect is important in den selection. Six dens were situated on basically flat ground, two were at the bottom of an esker slope and two were at the top.

Table 3.3-5
Fox Den Locations and Characteristics, 1994

Number of Entrances	Aspect (°)	Position on Slope[1]	UTM Easting[2]	UTM Northing[2]	General Location
15	0	0	518200	7174200	Airstrip
6	135	0	530470	7177620	Lac du Sauvage Esker
8	0	0	521065	7162281	N. Lac de Gras Esker
7	0	0	521030	7162700	N. Lac de Gras Esker
8	151	3	507290	7184300	Exeter Esker
9	153	3	506780	7184560	Exeter Esker
3	143	1	532893	7180803	South of Ursula Esker
4	180	0	535516	7180601	South of Ursula Esker
	144	0	536150	7180750	South of Ursula Esker
9	147	1	535950	7173730	Lac du Sauvage Esker

1: Position on slope: 1=top; 2=middle; 3=bottom, 0=top or flat.
2: UTM grid zone designation is 12.

Wolves

Within the wildlife study area, there were 17 observations of wolves adjacent to existing roads, the camp and the airstrip, and 17 observations outside of this area (Table 3.3-6). Of the latter, seven were solitary wolves. The largest number of wolves observed was a pack of 14 adjacent to the Exeter esker. Twelve wolves, likely belonging to the same pack, were seen the day before in the same general area.

A family group of at least six wolves, with an adult male, an adult female and four pups, occupied a den at the southern end of the Lac du Sauvage esker. This den

Table 3.3-6
Wolves Observed at Lac de Gras 1994[1]

Date	Observations	Age-Sex	UTM Easting[2]	UTM Northing[2]	General Location
Apr 23	1	Unknown			Near east end Exeter L.
Jun 16	1	Unknown			Ursula Watershed
Aug 10	5	1 adult female, 1 adult male, 3 juvenile	539500	7162200	Lac du Sauvage Esker
Sep 8	3	Unknown adult	540200	7177100	W. Duchess L.
Sep8	3	1 adult male, 2 adult female	539850	7161930	Lac du Sauvage Esker, wolf den
Sep 12	1	Unknown adult	516500	7189000	Ursula West Esker
Sep 12	1	Unknown adult	511400	7162800	Step Lakes No. 3
Sep 13	5	2 adult, 3 juvenile	539850	7161930	Lac de Sauvage Esker, wolf den
Sep 13	12	Various	508030	7188100	Ursula L. Esker & south
Sep 14	14	9 adult, 5 juvenile	517050	7187020	Between Exeter & Ursula
Sep 19	1	Unknown adult	510160	7184150	Exeter L. Esker
Sep 30	6	1 adult female, 1 adult male, 4 juvenile	539850	7161930	Lac de Sauvage Esker, wolf and bear dens
Oct 8	5	Unknown	539550	7162240	Lac du Sauvage Esker
Oct 8	1	Slipper Lake			
Oct 10	1+	Unknown	532475	7181065	Ursula S. Esker
Oct 17	1	Unknown adult	526200	7178200	S. of Ursula and Lac de Sauvage eskers
Oct 22	2	Unknown			13 km SE Koala Camp

1: Does not include the exploration camp, portals and roads. UTM coordinates were not obtained for three incidental observations .
2: UTM grid zone designation is 12.

was not used in July and August but was occupied on September 13. This family of wolves had used at least two dens during the summer, the first probably being outside the Lac de Gras project area.

In total, six wolf dens having two to ten entrances were found, all on eskers (Table 3.3-7). At least one of the dens with two entrances was excavated in the summer of 1994. Two dens had southerly aspects, two southeasterly, one was easterly and one was on flat ground (Table 3.3-7). Prey remains and hair on vegetation were evidence that all six dens were used for at least part of the summer. The den at the south end of the Lac du Sauvage esker appears to have been in use for the longest period.

Table 3.3-7
Wolf Den Locations and Characteristics 1994

No. of Entrances	Aspect (°)	Position on Slope[1]	UTM Easting[2]	UTM Northing[2]	General Location
4	180	1	531450	7188680	Ursula Esker (East)
6	127	0	532390	7180839	South of Ursula Esker
2	0	0	537311	7182454	South of Ursula Esker
2	132	0	531309	7180896	South of Ursula Esker
10	174	0	539850	7161930	Lac du Sauvage Esker
3	61	1	539150	7163150	Lac du Sauvage Esker

1: Position on slope: 1=top; 2= middle; 3=bottom, 0=top or flat.
2: UTM grid zone designation is 12.

The majority of the 17 wolf observations adjacent to the NWT Diamonds exploration camp were of two adult wolves. Wolves were also seen near the Panda and Fox portals, on the access road to the Fox portal and the Falcon exploration camp.

Wolverine

Seven of the 13 sightings of wolverine were on the Lac du Sauvage esker (Table 3.3-8). This, however, may not reflect actual distribution. In addition, ten wolverine were observed adjacent to the camp, roads and portals, suggesting the presence of at least one resident wolverine. Further, track data and observations from the winter of 1994/1995 supports that at least one resident wolverine was present in the area.

3.3.4.3 Food Habits

The food habits of foxes, wolves and wolverines at Lac de Gras are described, based on a limited number of scats collected over a brief period. Although this sample may not be representative, it suggests some of the foods that these carnivores consume. The use of certain prey such as birds and fish needs to be investigated with a larger sample size over a longer time period.

Scats were found at old and fresh caribou kill sites, on eskers and adjacent to dens. Scats could not always be identified to source. Fox scats could not be positively identified as arctic fox or red fox, nor could scats always be identified to wolf or to wolverine. Six scats representing four individual foxes, ten wolf/wolverine scats representing five animals and eight wolf scats from seven wolves were found during the fall of 1994.

Table 3.3-8
Wolverine Observed at Lac de Gras 1994 and Winter 1995[1]

Date	Age-Sex	UTM Easting[2]	UTM Northing[2]	General Location
Feb 28	Unknown			Larry Lake Esker
Apr 23	Unknown			Exeter Lake Esker
Jun 14	Unknown			Lac du Sauvage Esker
Aug 5	Unknown	533530	7176750	Lac du Sauvage Esker
Sep 2	Unknown	527950	7174050	Bat Lake
Sep 5	Unknown	514300	7175300	West-central Long Lake
Sep 15	Adult female	532160	7177275	Leslie Lake, south shore
Sep 21	Unknown	532160	7177900	Lac du Sauvage Esker
Sep 28	Adult male	536300	7173500	Lac du Sauvage Esker
Oct 6	Adult male	538400	7168170	Lac du Sauvage Esker
Oct 6	Adult male	538821	7167618	Lac du Sauvage Esker
Oct 11	Unknown	513939	7161759	East of Step Lakes
Oct 15	Unknown	541431	7163940	East of Lac du Sauvage Esker
Nov 25	Unknown	521900	7176300	Koala Creek
Jan 25	Unknown	518750	7174700	Fox Lake road
Jan 25	Unknown	522600	7182200	Vulture Lake
Jan 27	Unknown	514166	7181842	East of Little Exeter Lake
Jan 27	Unknown	509957	7183999	Exeter Lake Esker

1: UTM coordinates not obtained for three incidental observations.
2: UTM grid zone designation is 12.

Ten caribou kills were recorded between August 30 and October 10. The age of the kill ranged from fresh to an estimated 15 days. Only one kill appeared to be a natural mortality. Although wolverine, foxes and bears had scavenged on some of these kills, most of these caribou were killed by wolves, based on evidence at the kill site.

Caribou was a frequent prey item of furbearers (Tables 3.3-9 to 3.3-11). All furbearer species also consumed arctic ground squirrels, meadow voles (*Microtis pennsylvanicus*) and hares. Evidence of bird species, ptarmigan and passerines was also observed in scats.

3.3.4.4 Future Plans

Field work in 1995 will be a continuation of studies initiated in 1994. Sightings of furbearers, den locations and habitat use will be monitored. Monitoring plans are described within Volume III, Section 7.5.

Table 3.3-9
Food Items in Six Fox Scats
Collected September 10 to October 12, 1994[1]

Food Item	% Occurrence Range	% Occurrence Average	% Occurrence +/- sd	Number of Scats	Overall Average (in 6 scats)
Caribou	1 to 100	37	55	3	18
Microtis sp.	4 to 99	38	53	3	19
M. pennsylvanicus		100		1	17
Arctic Ground Squirrel		99		1	16
Hare[2]		100		1	17
Passerines[3]		80		1	13
Ptarmigan		96		1	16
Coleoptera (beetle)		Trace		1	Trace

1: Six scat collections from four individual arctic or red foxes. Trace represents <1%.
2: Arctic hare or Snowshoe hare.
3: Likely Horned Lark (*Eremophila alpestris*).

Table 3.3-10
Food Items in Ten Scats Collected
From Wolves or Wolverine September, 1994[1]

Food Item	% Occurrence Range	% Occurrence Average	% Occurrence +/- sd	Number of Scats	Overall Average (in 10 scats)
Caribou Calf	20 to 100	75	31	6	35
Caribou Yearling or Adult	90 to 100	95	5	4	30
Arctic Ground Squirrel	5 to 40	17	17	4	7
Microtis sp.	5	5	0	2	1
M. pennsylvanicus		1		1	Trace
Arctic fox		1		1	Trace
Anatidae[2]		40		1	4
Hare[3]		20		1	2
Passerine		20		1	2
Egg - passerine		5		1	Trace
Fish		1		1	Trace

1: Could not identify to wolf or wolverine; ten scat collections from five animals; "trace" represents <1% occurrence.
2: Likely Oldsquaw (Clangula hyemalis).
3: Arctic hare or snowshoe hare.

Table 3.3-11
Food Items in Eight Scats
Confirmed as Wolf, Collected September, 1994[1]

Food Item	% Occurrence Range	Average	+/- sd	Number of Scats	Overall Average (in 8 scats)
Caribou Calf		100	0	2	25
Caribou Yearling or Adult	95 to 100	99	2	6	74
Arctic ground squirrel		5		1	Trace
M. pennsylvanicus		1		1	Trace
Ptarmigan		1		1	Trace

1: Eight scat collections from seven wolves; "trace" represents <1% occurrence.

3.3.5 Small Mammals And Hares

Small mammals consist of voles, mice, lemmings and shrews. Voles and mice expected at Lac de Gras include the northern red-backed vole (*Clethrionomys rutilus*), meadow vole (*Microtis pennsylvanicus*), chestnut-cheeked vole (*Microtis xanthognathus*) and white-footed deer mouse (*Peromyscus maniculatus*) (Shank 1993). Two lemming species were recorded, brown lemmings (*Lemmus sibiricus*) and collared lemmings (*Dicrostonyx torquatus*). Little information is available on the occurrence and distribution of shrew species (*Sorex* spp.) in the Southern Arctic Ecozone. For this discussion, the term "small mammals" also includes arctic ground squirrels, the only squirrel species within the Southern Arctic Ecozone. Two hare species were observed at Lac de Gras, arctic hares and snowshoe hares, although the latter appear to be rare.

Small mammals and hares are important prey for carnivores such as arctic and red foxes and for avian predators. These prey are not migratory and are available all winter, if foxes and wolverine can access them. Ground squirrels are an important food for many carnivorous species, including grizzly bears. They establish their burrows in glacial-fluvial deposits, using eskers to a large extent. Ground squirrels hibernate but wolverine have been known to dig them out of their hibernacula (Gardner 1985). Lemmings and voles remain active under the snow and hares are active above ground.

Small mammals and hares are one component of the biodiversity within the Southern Arctic Ecozone. They are considered a valued ecosystem component because of their importance in the arctic food chain. Small mammals and hares may, at times, be an important food for carnivores, especially when caribou are unavailable. At Lupin, an increase in arctic hares in dump sites has resulted in an increase in wolverines and wolves and thus Inuit hunting activity (see above). In the uncertainty of the harsh arctic environment, the more diverse the prey base, the better the odds for survival.

3.3.5.1 Previous Research

In the Northwest Territories, small mammals and hares tend to be cyclic, with tremendous fluctuations in population sizes. These fluctuations are often regular (every three to four years) and large in magnitude with populations at the high varying ten to 50 times populations at the low. The abundance of small mammals and hares affects the behaviour, use of habitats and population dynamics of the species that prey on them. Rough-legged hawks (*Buteo lagopus*) and Snowy Owls (*Nyctea scandiaca*) choose areas of high microtine and lemming numbers in which to breed (Galushin 1974; Pitelka *et al.* 1955). Grizzly bears key in on habitats with ground squirrel burrows in the fall. A cyclic relationship appears between arctic foxes and lemmings, but the nature of the relationship is poorly understood (MacPherson 1969).

Fluctuations in small mammal populations can affect species other than carnivores. When small mammal numbers are low, prey switching by generalized predators such as arctic fox, wolves and wolverine can affect waterfowl breeding success (Sutherland 1988). When numbers are high, the vegetation can be significantly reduced, affecting the availability of food for other herbivores. For example, during a peak year at Baker Lake in the Northwest Territories, lemmings utilized about 15% of vegetative standing crop (Krebs 1964).

3.3.5.2 Future Plans

Two trapping sessions, during summer and fall, stratified by habitat are planned for 1995 to determine distribution. At least one trapping session will be part of the ongoing wildlife monitoring program. A small mammal trapping program for the Northwest Territories is currently in progress, under the direction of the Department of Renewable Resources (Shank 1993). This information will assist in documenting cyclic trends in populations and in predicting yearly prey availability for predators such as raptors and furbearers.

3.3.6 Birds

The Northwest Territories (NWT) is home to few year-round residents of birds but hosts immense numbers of migratory species during the brief snow-free period. The importance of the NWT for nesting and brood-rearing is evident in its 16 migratory bird sanctuaries covering 11 million hectares of arctic coastal habitat (Graves and Hall 1988). Most of these sanctuaries are for the protection of waterfowl. One-fifth of the North American population of all ducks, geese and swans nest in the NWT (Graves and Hall 1988).

Birds are considered a valued ecosystem component because of their tremendous diversity in morphology, ecological function and use of habitats. Some species, in particular waterfowl and ptarmigan, are important to Aboriginal and non-aboriginal residents for food. The presence of bird species has been used as an ecological indicator to monitor environmental health. For example, waterfowl species are associated with wetlands, a relatively rare habitat type in the central arctic. Wetlands are not only used by birds but also by grizzly bears in the spring and barren-ground caribou in the fall (Section 3.2).

Some passerine species nest in tall shrubs, another relatively rare vegetation community in riparian habitats also used by grizzlies and wolves. Continued use of these important habitats by birds may be viewed as evidence that the overall integrity of these ecosystems is being maintained. Birds have also been used as ecological indicators because of their role in the ecosystem. Species feeding on fish, such as loons and colonial waterbirds, and birds of prey are at the top of their food chains. As such, contaminants that have been consumed by species occupying lower trophic levels will become concentrated in the tissues of birds.

Although many migratory species use arctic habitats for only a few months of the year, these areas are important because birds are dependent on them for breeding and nesting. The NWT Diamonds Project and surrounding area are small compared to the length and breadth of bird migratory pathways. However, assessing relative abundance and distribution of species is useful because birds can be used to monitor changes in the quality and quantity of habitats over time as development proceeds.

The objectives of bird studies undertaken in 1994 were to determine the species that breed in or migrate through the Lac de Gras area, the timing of the spring and fall migration and the distribution and use of habitats by birds, particularly within the Koala watershed. These results are preliminary, as systematic surveys were not conducted for birds to any great extent. More intensive studies are being conducted in 1995. A general statement that can be made, however, is that compared to the Central Arctic to the north or the taiga to the south, the bird fauna within the central Southern Arctic Ecozone, including Lac de Gras, is low in species abundance and diversity.

Ravens were the first to arrive within the wildlife study area, observed on May 2. Canada Geese were the first migrants, observed on May 5. White-fronted Geese were not observed until May 15. Loons were present in mid-June, bred and nested at Lac de Gras and some species remained until early October. Arctic Terns arrived in late May. Gulls and Jaegers were not observed until the second week of July, although gulls most likely were within the wildlife study area since mid-May. Data on the arrival of birds of prey and passerines were not obtained. The fall migration through Lac de Gras appeared to be sporadic and quick. The largest waterfowl flock observed within the Koala watershed at this time was 14 Canada Geese. Elsewhere, the largest flock observed was 50 Canada Geese.

3.3.6.1 Previous Research

Bird census plots have been described for the Arctic islands and mainland, Arctic/Hudson Bay coast and the Mackenzie Delta (Johnston *et al*. 1994; Dickson *et al*. 1983; Erskine 1984; Freedman and Svoboda 1982), but only limited data are available for the Southern Arctic Ecozone. In particular, major staging areas of waterfowl throughout southern Canada are well documented (USDI 1984), but they are relatively unknown in the central Canadian Arctic. Similarly, research has focused on nesting of raptors, but little is known about migration routes and habitat use during migration (Kochert 1986). The baseline data collected at Lac de Gras and ongoing monitoring will provide new information on the occurrence and distribution of bird species within the central Southern Arctic Ecozone. In conjunction with coastal studies and taiga studies, a greater understanding of migratory species will be obtained.

3.3.6.2 Methods

Field studies conducted during 1994 were primarily focused on lakes within the Koala watershed (Figure 3.3-18), although an attempt was made to determine bird use of the wildlife study area during the fall migration. The objective was to examine in detail bird occurrence in areas directly affected by development and, more generally, to understand bird use of the surrounding area.

Methods consisted of ground and aerial helicopter surveys. A second source of information was incidental observations recorded by Rescan biological staff, helicopter pilots and residents of the exploration camp during all field activities. Because of the number of people at the Camp and the extent of their activities, incidental observations became a valuable contribution. Such information, however, must be viewed judiciously because of the difficulty in identifying birds, especially for inexperienced observers.

Local Study Area: The shorelines of 15 lakes within the Koala watershed were surveyed by foot or by boat from July 11 to 18. Shorelines of these lakes were also observed by helicopter on August 17, August 27 and September 9. Species and numbers of birds observed were documented. Wildlife observations for Misery Lake were documented by Rescan staff during baseline fisheries and environmental data collections, and the shoreline was surveyed by helicopter in October 1994.

Wildlife Study Area: The wildlife study area was surveyed by flying eleven 1 km wide parallel transects. These transects were established north to south, 25 to 31 km in length and 4 km apart, and were navigated using a GPS. Transects were

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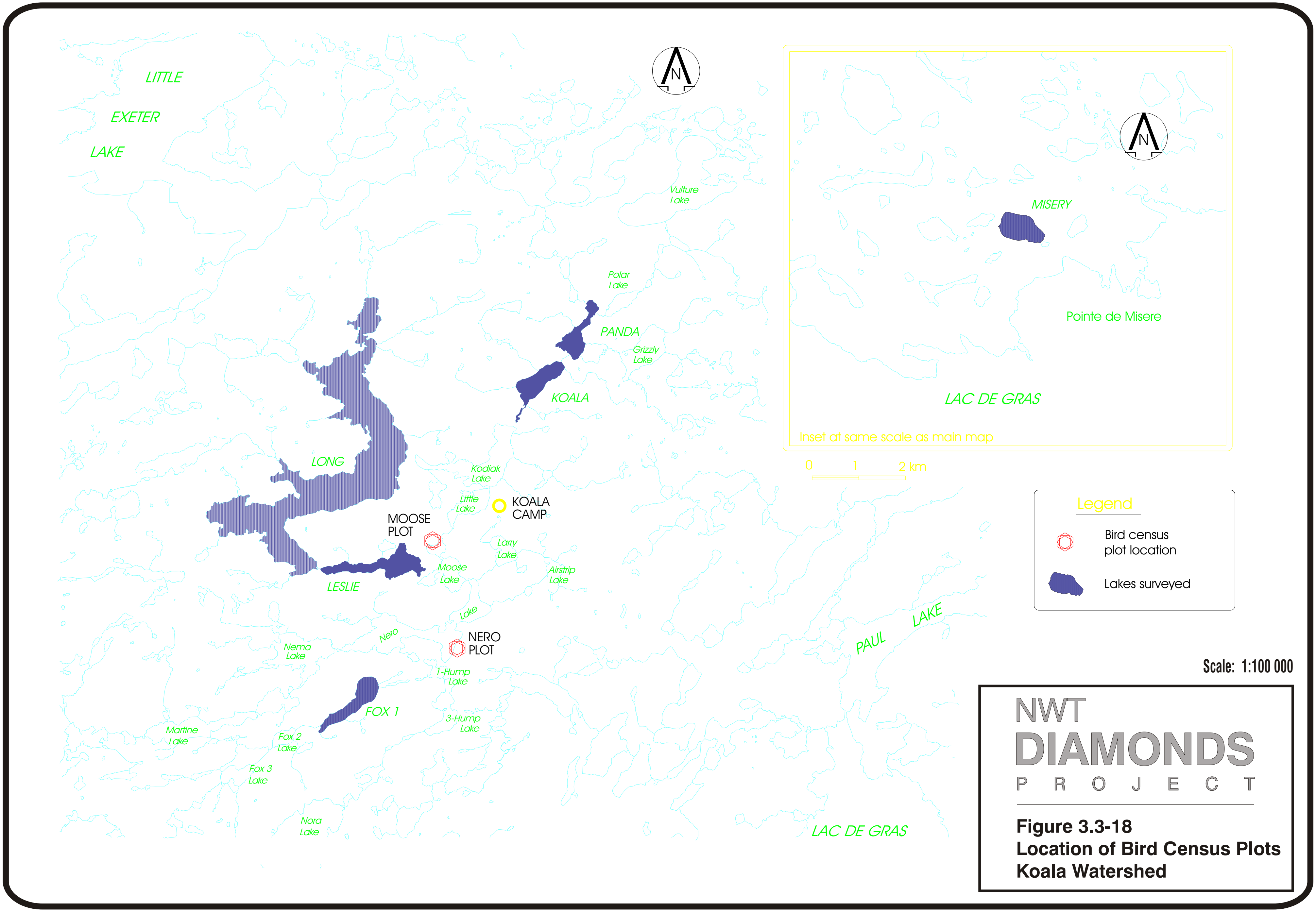

Figure 3.3-18
Location of Bird Census Plots
Koala Watershed

Source: Rescan

flown on September 12 shortly after dawn by helicopter at a speed of 160 km/h and an elevation of 60 m. Two observers scanned a 500 m transect on each side of the helicopter and called out sightings of birds and other wildlife. The recorder documented these observations in addition to sightings directly ahead of the helicopter.

The following day, the shorelines of eight randomly selected lakes were walked and species of birds observed were recorded. The objectives of these surveys were to verify species composition. Surveys were conducted daily in the mornings from September 13 to 16.

Breeding Bird Surveys: Preliminary information on the nesting activity of passerines within the Koala watershed was determined by surveying two plots. These were 12.5 ha and 25 ha in size and located at Moose and Nero lakes, respectively, in the Koala watershed (Figure 3.3-18). These plots were selected due to ease of access from the exploration camp as well as being in undisturbed areas.

Transects were located 100 m apart and marked with flagging tape. Lengths of transect lines were 250 m for the Moose plot and 500 m for the Nero plot. Birds were counted either in the morning or in the evening by walking the transects and recording, by species, all birds in adult plumage seen within 50 m of the line. Four counts were conducted on each plot between July 12 and 18.

3.3.6.3 Species Occurrence and Migration

The species list in Table 3.3-12 is incomplete and preliminary, as the data on bird distribution and abundance were limited, especially during the spring migration. Times when birds were first observed and flock sizes are presented and will be confirmed during 1995.

No large flocks of waterfowl were seen over Lac de Gras in the summer, nor the fall. The largest flock, 50 Canada Geese, was observed during the fall. No large groups of staging waterfowl were observed. However, whether such flocks migrated over Lac de Gras during the night is not known, nor is the spring migration. Canada Geese were the first migrants, observed on May 5. White-fronted Geese were not observed until May 15. The earliest passerines, Common Ravens, were first observed on May 2. As birds were not observed systematically, the dates that birds were first seen are not indicative of spring migration for all species.

Migratory species departed gradually rather than as a mass exodus. Loon species were observed as late as October 2. Waterfowl species were not observed past the end of September. Raptors were seen into October. The latest was a Bald Eagle

Table 3.3-12
Birds Observed During 1994 Within the Lac de Gras Area[1]

Common Name	Scientific Name
ORDER GAVIIFORMES: Loons	
Red-throated Loon	*Gavia stellata*
Pacific Loon	*Gavia pacifica*
Common Loon	*Gavia immer*
ORDER ANSERIFORMES: Swans, Geese and Ducks	
Tundra Swan	*Cygnus columbianus*
Greater White-fronted Goose	*Anser albifrons*
Snow Goose	*Anser caerulescens*
Canada Goose	*Branta canadensis*
Oldsquaw	*Clangula hyemalis*
Scoter spp.	*Melanitta spp.*
Red-breasted Merganser	*Mergus serrator*
ORDER FALCONIFORMES: Diurnal Birds of Prey	
Bald Eagle	*Haliaeetus leucocephalus*
Rough-legged Hawk	*Buteo lagopus*
Golden Eagle	*Aquila chrysaetos*
Peregrine Falcon	*Falco peregrinus tundrius*
Gyrfalcon	*Falco rusticolus*
ORDER GALLIFORMES: Ptarmigan	
Willow Ptarmigan	*Lagopus lagopus*
Rock Ptarmigan	*Lagopus mutus*
ORDER CHARADRIIFORMES: Shorebirds, Gulls and Allies	
American Golden-Plover	*Pluvialis dominica*
Least Sandpiper	*Calidris minutilla*
Stilt Sandpiper	*Calidris himantopus*
Red-necked Phalarope	*Phalaropus lobatus*
JAEGERS	
Parasitic Jaeger	*Stercorarius parasiticus*
Long-tailed Jaeger	*Stercorarius longicaudus*
GULLS AND TERNS	
Herring Gull	*Larus argentatus*
Glaucous Gull	*Larus hyperboreus*
Arctic Tern	*Sterna paradisaea*
Short-eared Owl	*Asio flammeus*

(continued)

Table 3.3-12 (completed)
Birds Observed During 1994 Within the Lac de Gras Area[1]

Common Name	Scientific Name
ORDER PASSERIFORMES: Perching Birds	
Flycatcher spp.	*Contopus* spp.
Horned Lark	*Eremophila alpestris*
Common Raven	*Corvus corax*
American Robin	*Turdus migratorius*
American Pipit	*Anthus spinoletta*
American Tree Sparrow	*Spizella arborea*
Savannah Sparrow	*Passerculus sandwichensis*
White-crowned Sparrow	*Zonotrichia leucophrys*
Harris' Sparrow	*Zonotrichia querula*
Lapland Longspur	*Calcarius lapponicus*
Snow Bunting	*Plectrophenax nivalis*
Common Redpoll	*Carduelis flammea*

1: Italicized common names are those species listed on Appendix II of the Convention on the Conservation of Migratory Species of Wild Animals.

observed on October 15. As gulls and Ravens were common, there was a tendency to not record all sightings on the wildlife log (Table 3.3-12). However, these species were the longest residents and were present into November.

A survey conducted along the south shore of Lac de Gras from July 10 to 12 in 1993 documented most of the same species observed in 1994. The earlier survey recorded the following additional species: Common Merganser (*Mergus merganser*), Yellow Warbler (*Dendroica petechia*), Smith's Longspur (*Calcarius pictus*) and Hoary Redpoll (*Carduelis hornemanni*) (J. Obst, pers. comm. 1995). It is likely that future work will confirm the presence of these species on the north shore of Lac de Gras.

Species occurrence is discussed below by Order. A description of basic biology is included to provide an understanding of the species' ecological role and use of habitats.

A. Loons (Gaviiformes)

Loons are large-bodied birds associated with lakes. Their primary diet consists of small fish. Three loon species were observed within the regional study area (Table 3.3-12).

B. Waterfowl (Anseriformes)

Waterfowl are comprised of geese, ducks and swans. Habitat features for different species vary considerably throughout the year as a result of geographic differences and seasonal availability of food.

Summer habitat for waterfowl typically consists of wetlands and lakes. They feed primarily on aquatic plants, including seeds, stems and tubers of submergents and emergents and use upland sources once marshes freeze. In the spring, berries, especially crowberry (*Empetrum nigrum)* and bilberries (*Vaccinium uliginosum*), newly exposed by melting snow can be important foods (R. Bromley, pers. comm. 1995).

Waterfowl observed at Lac de Gras included the Tundra Swan and three species of geese: Canada, Greater White-fronted and Snow (Table 3.3-12). Tundra swans nest in the Arctic from north of Hudson Bay to the coast of Alaska (Bellrose 1978). Of the geese species, Canada Geese have the greatest morphological and ecological breadth, with sizes ranging from a large duck to a small swan, and nesting habitat including farm ponds to forested lakes to arctic tundra (Eng 1986a).

Three species of ducks were observed at Lac de Gras, Oldsquaw, *Scoter* spp. and the Red-breasted Merganser (Table 3.3-12). The absence of dabbling ducks may be explained by the absence of extensive marsh habitat, used for nesting and foraging. Conversely, animal foods comprise 100% (largely fish) of the diet for mergansers and 70% to 95% for species such as Scoters, primarily crustaceans and mollusks taken during bottom feeding. Oldsquaws also will eat aquatic plants and freshwater invertebrates. Duck hunting was traditionally a major activity when Dene spent the summer in Ek'ati tata, while waiting for the caribou to arrive (Susie Mackenzie, Rae Lakes).

C. Diurnal Birds of Prey (Falconiformes)

Raptors, typically at low densities, often nest in inaccessible areas such as cliffs and rugged terrain. They can be difficult to find and are wide-ranging and rapid moving (Kochert 1986). Raptors are linked to specific habitat features and their presence can often be predicted by the presence of certain habitat characteristics (Kochert 1986). Nesting requirements and the availability of food are the two most important factors regulating their abundance and distribution (Kochert 1986).

Raptor species observed within the regional study area during 1994 include Bald and Golden Eagles, Rough-legged Hawks, Peregrine Falcons and Gyrfalcons (Table 3.3-12). Nesting by Peregrines was confirmed in 1994, outside of the development area. Raptors were first observed in mid-July but may have been present earlier, particularly nesting eagles and falcons. There was one sighting of a

Gyrfalcon on July 12. More than one Gyrfalcon likely existed in the study area and were identified solely as hawks. Bald Eagles were observed as late as October 15.

Limited habitat for cliff nesters such as Peregrine Falcons, Gyrfalcons and Golden Eagles is available at Lac de Gras, although largely lacking in the Koala watershed, Golden Eagles will use other elevated features, such as eskers, for nesting. Rough-legged Hawks nest on eskers, small cliffs and occasionally on the ground. Being carnivorous, most raptors prey on rodents, other small mammals and small game birds. Some species, particularly Bald Eagles, feed on fish.

D. Ptarmigan (Galliformes)

Ptarmigan are chicken-like birds commonly known as arctic grouse. While they are non-migratory, a significant southward movement takes place during the winter within the Northwest Territories (J. Obst, pers. comm.). Ptarmigan are an important food for raptors and mammals such as arctic fox, red fox and wolverine. As they are permanent residents, they are an important prey during winter when other birds and caribou are absent.

Willow and Rock Ptarmigan are the only two species recorded within the regional study area. They were observed in all watersheds, separated by differences in habitat preferences. Willow Ptarmigan inhabit open tundra and show a preference for level to moderate terrain heavily vegetated with grasses, forbs and shrubs (Eng 1986b). Rock Ptarmigan use more hilly terrain with less luxuriant vegetation (Eng 1986b). Willow (*Salix* spp.) buds and twigs are a dominant food for a large part of the year for both species. During the spring and summer, both species feed on leaves and berries of cranberry (*Vaccinium vitis-idaea*), bilberry (*Vaccinium uliginosum)*, crowberry (*Empetrum nigrum*), horsetail tips (*Equisetum* spp.) and Dryas (*Dryas* spp.) leaves (Eng 1986b).

E. Marsh Birds (Gruiformes)

Sandhill Cranes (*Grus canadensis*) are large marsh birds typically found at low densities (Eng 1986a). One Sandhill Crane was seen flying north over the exploration camp on May 2, the only observation of this species.

F. Shorebirds, Jaegers, Gulls and Terns (Charadriiformes)

This order has great diversity in habitats, life cycles and behaviour (Eng 1986a). Individual species differ in their habitat preferences, but total densities are usually highest during the breeding season on tundra of variable topography with numerous shallow wet troughs or small ponds (Eng 1986a). This combination provides habitat for nesting and foraging for several of the most common species and is most prevalent in coastal tundra (Eng 1986a).

Shorebirds

Shorebirds are a diverse group and include sandpipers, plovers, phalaropes, snipe, godwits and curlews. Some species gather in immense flocks at staging areas, often in coastal habitats, where they feed primarily on benthic invertebrates in intertidal zones (Gratto-Trevor 1994). Most shorebirds breeding in arctic Canada winter in the southern United States or Central or South America.

The shorebird species observed in the Koala watershed were few and included the Lesser Golden Plover, Least Sandpiper, Stilt Sandpiper and Red-necked Phalarope (Table 3.3-12). As shorebird habitats consist of fields, marshes, beaches and mud flats, habitats that are largely uncommon in the Koala watershed, it is not surprising that such shorebirds were rare in the project vicinity. Ongoing and future studies will delineate the use of the wildlife study area by shorebirds.

Jaegers, Gulls and Terns

Jaegers are gull-like, swift predatory sea birds that spend most of the year on the ocean but nest on the arctic tundra (Godfrey 1986). Their diet consists of fish, small mammals, large insects, occasionally adult birds and the eggs and young of other birds as carrion. They will also scavenge off carrion and the kills of raptors. Long-tailed Jaegers were sighted 22 times at Lac de Gras while Parasitic Jaegers were observed twice. Nesting by Long-tailed Jaegers was confirmed.

In ideal habitat, gulls and terns are colonial nesters. On the tundra, however, they nest mostly in single pairs. They have variable diets that may include fish, aquatic invertebrates, eggs and young of other birds, larger insects, if available, and occasionally mice and wild berries (Godfrey 1986). They also scavenge. These species are near or at the top of the food chain and are sensitive to the health of freshwater ecosystems. Their reproductive success has been used as an indicator of contaminants in the environment (Speich 1986).

Arctic Terns appeared to be common at Lac de Gras. Breeding and nesting were confirmed. The Herring Gull, a broadly distributed bird that uses various types of shores and islands (Godfrey 1986), was observed in all watersheds and in all habitat types at Lac de Gras. Nesting on the island at Long Lake was confirmed. This is typical nesting habitat as Herring Gull nests tend to be associated with lakes, on rocky islands, low islets and large boulders (Godfrey 1986). It is likely other gull species are present within the wildlife study area, although only a Glaucous Gull was identified during 1994.

G. Owls (Strigiformes)

One owl species, the Short-eared Owl, was observed within the wildlife study area. This species is a ground-nester and was typically associated with tall shrubs of willow, often in riparian areas.

H. Perching Birds (Passeriformes)

The species within the Passerine Order are diverse, as are their habitat requirements. Passerines live wherever there is sufficient cover for nesting and where habitats provide appropriate foods. Most are extremely mobile and have relatively high breeding potential, with great fluctuations in numbers from season to season (Ryder 1986). Passerines observed within the wildlife study area are listed in Table 3.3-12.

3.3.7 Local Study Area: Plot Surveys

The two survey plots within the Koala watershed evaluated for breeding birds contained both shoreline and tundra habitat (Table 3.3-13). Tall shrub was a rare vegetation community within these plots, not present at all at Moose Lake and comprising only 1% in the Nero Lake plot (Table 3.3-13). Thus, birds using this habitat type were under-represented in these surveys.

Table 3.3-13
Characteristics of Breeding Birds Survey Plots
at Moose and Nero Lakes

	Moose Lake Plot	**Nero Lake Plot**
Size (ha)	12.5	25
Elevation (m)	444 - 451	444 - 462
Topography	Flat/gently sloping	Rolling
Slope	2%	2 - 15%
Aspect	Southeast	Variable
Shoreline Length	250 m	150 m
Vegetation		
Rocky Tundra	20%	90%
Tussock Tundra	80%	9%
Tall Shrub	0%	1%

Plot surveys were conducted toward the end of the breeding season, yet male passerines were still engaged in territorial singing. Nine species of passerine birds and six non-passerines were recorded on the plots (Tables 3.3-14 and 3.3-15). Willow Ptarmigan appeared to nest on both plots, whereas the Least Sandpiper

Table 3.3-14
Breeding Bird Counts at Nero Lake Plot, July 1994

Species	Number of Adults					
	12 Jul	13 Jul	17 Jul	18 Jul	Total	% of Total
Willow Ptarmigan	2	5	6	2	15	10%
Long-tailed Jaeger				2	2	1%
Flycatcher spp.	1				1	1%
Horned Lark	2	2			4	3%
American Tree Sparrow	7	9	6	4	26	17%
Savannah Sparrow		1	2	5	8	5%
White-crowned Sparrow	9	6			15	10%
Harris' Sparrow	7	14	7	5	33	22%
Lapland Longspur	20	8	5	3	36	24%
Common Redpoll	2	1	4	4	11	7%
Total	**50**	**46**	**30**	**25**	**151**	**100%**

Table 3.3-15
Breeding Bird Counts at Moose Lake Plot, July 1994

Species	Number of Adults					
	14 Jul	15 Jul	17 Jul	18 Jul	Total	% of Total
Willow Ptarmigan		1	2		3	4%
Least Sandpiper			5	5	10	13%
Red-necked Phalarope	1	1	1	1	4	5%
Long-tailed Jaeger				2	2	3%
Arctic Tern				2	2	3%
Herring Gull			1		1	1%
Horned Lark			1		1	1%
American Tree Sparrow	5	2	3	2	12	15%
Savannah Sparrow	3	5	3	74	18	23%
Harris' Sparrow	1			2	3	4%
Lapland Longspur	5	3	6	8	22	28%
Total	**15**	**12**	**22**	**298**	**78**	**100%**

and Red-necked Phalarope were seen only at Moose Lake. The Least Sandpiper and Red-necked Phalarope were associated with lake shorelines. Only the Horned Lark was found on barren hilltops. All other species were found on either rocky tundra or tussock tundra.

Densities of breeding pairs of birds (total number/2) were estimated as 74 pairs per 100 ha for the Nero Lake plot and 73 per 100 ha for the Moose Lake plot. These values fall within the large range of two to 200 pairs per 100 ha of tundra in 15 arctic bird studies reviewed by Freedman and Svoboda (1982). Although these results are preliminary and may not be representative of the Koala watershed, they provide a minimum estimate of the species breeding in the area.

Densities of breeding pairs of birds (total number/2) were estimated as 74 pairs per 100 ha for the Nero Lake plot and 73 per 100 ha for the Moose Lake plot. These values fall within the large range of two to 200 pairs per 100 ha of tundra in 15 arctic bird studies reviewed by Freedman and Svoboda (1982). Although these results are preliminary and may not be representative of the Koala watershed, they provide a minimum estimate of the species breeding in the area.

3.3.7.1 Local Study Area: Waterfowl Surveys

No birds were observed during ground and aerial waterfowl surveys on Blip, Airstrip and Larry lakes (Table 3.3-16) while four, five and ten species, respectively, were documented on these same lakes from incidental observations (Table 3.3-17). More species were observed during waterfowl surveys than incidentally, with six versus three species at Kodiak and five species versus zero at Leslie. No birds were observed at Fox 2 during surveys or incidentally, suggesting habitat is poor. Fox 2 is a relatively small lake, only 0.12 km^2 in area with a shoreline length of 1.6 km, with little shoreline vegetation.

Fewer visible species such as passerines and small waterfowl were observed more frequently during incidental observations than waterfowl surveys. Ground surveys did not document the same diversity of species seen incidentally. These results suggest that bird use of lake habitats was variable and that a greater survey effort is required. Incidental observations represented more observation days, more observers and, in general, quieter means of observing. They include sightings by persons on the ground, in boats and in vehicles. Not only would visibility be greater in these cases, but there would also be less disturbance than from helicopter surveys.

Species Composition: There were differences in species composition among lakes. Loons were observed on many lakes in the Lac de Gras area but were absent from the following lakes within the Koala watershed: Koala, Kodiak, Blip, Little, Larry, Leslie, 1-Hump, Tri-Hump and Fox 2 (Tables 3.3-16 and 3.3-17). Their absence was probably related to the meager shoreline habitat and few food supplies in the form of fish in these lakes.

From the waterfowl surveys and incidental sightings, Moose and Long lakes had the largest number of bird species, 16 each. Panda and Fox 1 lakes each had 11 species, and Larry Lake had ten species (Table 3.3-18). When species

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Table 3.3-16
Ground and Aerial Waterfowl Surveys of Sixteen Lakes in the Koala Watershed

Date	Lakes Surveyed							
Ground	**Grizzly**	**Panda**	**Koala**	**Kodiak**	**Blip**	**Little**	**Moose**	**Airstrip**
July 11 to 18	None observed	2 Arctic Tern 2 Herring Gull	2 Herring Gull	2 Red-necked Phalarope	None observed	1 Least Sandpiper	2 Common Loon	None observed
				12 Least Sandpiper		2 Arctic Tern 2 Herring Gull	2 Canada Geese	
				1 Stilt Sandpiper			1 Red-Breasted Merganser	
				6 Arctic Terns 2 Herring Gull			1 Red-necked Phalarope	
							3 Least Sandpiper	
							6 Arctic Tern	
							1 Herring Gull	
Aerial:								
August 17	None observed	1 Herring Gull	None observed	2 Herring Gull	None observed	None observed	None observed	None observed
August 27	None observed	1 Rough-legged Hawk	2 Herring Gull 1 Raven	None observed	None observed	1 Arctic Tern	None observed	None observed
September 09	2 Arctic Tern	2 Herring Gull 1 Rough-legged Hawk	10 Canada Geese	8 Red-Breasted Merganser	None observed	None observed	None observed	None observed

(continued)

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Table 3.3-16 (completed)
Ground and Aerial Waterfowl Surveys of Sixteen Lakes in the Koala Watershed

Date	Lakes Surveyed							
Ground	**Larry**	**Leslie**	**Long**	**Nero**	**1-Hump**	**Tri-Hump**	**Fox 1**	**Fox 2**
July 11 to 18	None observed	1 Red-breasted Merganser 1 Least Sandpiper 1 Herring Gull	1 Common Loon 1 Oldsquaw 4 Red-breasted Merganser 1 Least Sandpiper 7 Arctic Tern 2 Herring Gull	1 Red-breasted Merganser 4 Herring Gull	None observed	None observed	2 Pacific Loon 4 Herring Gull	None observed
Aerial:								
August 17	None observed	1 Herring Gull 1 Red-breasted Merganser	3 Herring Gull 5 Red-breasted Merganser	4 Herring Gull 1 Red-breasted Merganser	None observed	1 Rough-legged Hawk	3 Herring Gull	None observed
August 27	None observed	4 Geese	1 Herring Gull	1 Herring Gull	1 Herring Gull	None observed	None observed	None observed
September 09	None observed	2 Herring Gull 1 Rough-legged Hawk	1 Herring Gull	1 Red-breasted Merganser 2 Herring Gull	None observed	None observed	1 Herring Gull	None observed

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Table 3.3-17
Incidental Sightings of Birds Associated with or near Lakes in the Koala Watershed During May to October 1994

	Lakes Surveyed							
Date	**Grizzly**	**Panda**	**Koala**	**Kodiak**	**Blip**	**Little**	**Moose**	**Airstrip**
May 1 to 15				20 White-fronted Geese				
June 1 to 15	1 Lesser Golden Plover	4 Oldsquaw	1 Long-tailed Jaeger					
			4 Arctic Tern					
June 16 to 30		1 Lapland Longspur		1 Long-tailed Jaeger				
July 1 to 15	1 Lesser Golden Plover (chick)	1 Red-throated Loon	1 Parasitic Jaeger				4 Common Loon	1 Common Loon
		1 Red-necked Phalarope					4 Canada Geese	1 Long-tailed Jaeger
		2 Long-tailed Jaeger					2 Loon (unk)	
		1 Arctic Tern					1 Red-necked Phalarope	
		5 Herring Gull					5 Arctic Tern	
		2 White-crowned Sparrow					4 Herring Gull	
							1 Flycatcher sp.	
							1 American Tree Sparrow	
							1 Harris' Sparrow	

(continued)

Table 3.3-17 (continued)
Incidental Sightings of Birds Associated with or near Lakes in the Koala Watershed During May to October 1994

	Lakes Surveyed							
Date	**Grizzly**	**Panda**	**Koala**	**Kodiak**	**Blip**	**Little**	**Moose**	**Airstrip**
							4 Lapland Longspur	
							1 Common Redpoll	
July 16-31	1 Loon (unk)	1 American Robin	1 American Robin	12 Least Sandpiper			1 Pacific Loon	2 Arctic Tern
	2 Lapland Longspur			1 Long-tailed Jaeger			2 Long-tailed Jaeger	1 Herring Gull
							2 Herring Gull	
							1 American Tree Sparrow	
Aug 1-15					1 Long-tailed Jaeger		1 Harris' Sparrow	
					1 Horned Lark		2 White-fronted Geese	
					1 American Tree Sparrow		1 Long-tailed Jaeger	
					1 White-crowned Sparrow		Arctic Tern (4 Ad, 2 Juv)	
Aug 16-31							2 Herring Gull	
Sept 1-15			1 Short-eared Owl					
Sept 16-31		2 Scoter sp.	1 Golden Eagle			4 Snow Geese		
Oct 1-15			1 Bald Eagle					4 Tundra Swan

1: Age indicated if known, Ad = Adult, Juv = Juvenile. (unk)= species unknown.

(continued)

Table 3.3-17 (continued)
Incidental Sightings of Birds Associated with or near Lakes in the Koala Watershed During May to October 1994

Date	Lakes Surveyed					
	Larry	Long	Nero	Tri-Hump	Fox 1	Koala Camp
May 1-15						
May 16-31						1 Arctic Tern
June 1-15						
June 16-30				1 Red-throated Loon		
July 1-15	3 Lesser Golden Plover	2 Bald Eagle	1 Loon (unk.)		2 Arctic Loon	
	1 Stilt Sandpiper	1 American Tree Sparrow	2 Long-tailed Jaeger		1 Lesser Golden Plover	
	1 Red-necked Phalarope	1 White-crowned Sparrow	4 Herring Gulls		2 Long-tailed Jaeger	
	2 Herring Gulls	3 Lapland Longspur	3 American Tree Sparrow		2 Herring Gull (+ chicks)	
	2 Lapland Longspur		1 Harris' Sparrow		1 Flycatcher sp.	
			5 Lapland Longspur		1 Horned Lark	
July 16-31	1 Least Sandpiper	1 Common Loon	4 Long-tailed Jaeger	1 Rough-legged Hawk	2 Long-tailed Jaeger	1 Arctic Tern
	4 Long-tailed Jaeger	1 Loon (unk)	1 Arctic Tern	1 American Robin	1 Herring Gull	1 Least Sandpiper
	2 Arctic Tern	1 Rough-legged Hawk	4 Herring Gull	1 American Pipet	1 Horned Lark	2 American Pipet
	1 Lapland Longspur	1 Short-eared Owl	1 White-crowned Sparrow	2 Harris' Sparrow	1 American Pipet	
	5 Common Redpoll		3 Common Redpoll		2 Harris' Sparrow	
					4 Lapland Longspur	
Aug 1-15			1 American Tree Sparrow		1 Red-throated Loon	
			3 White-crowned Sparrow		3 Long-tailed Jaeger	
			2 Harris' Sparrow		1 Lapland Longspur	

(continued)

Table 3.3-17 (completed)
Incidental Sightings of Birds Associated with or near Lakes in the Koala Watershed During May to October 1994

	Lakes Surveyed					
Date	**Larry**	**Long**	**Nero**	**Tri-Hump**	**Fox 1**	**Koala Camp**
Aug 16-31		6 Canada Geese				
Sept 1-15		2 Red-throated Loon				
Sept 16-31	5 Tundra Swan (Larry-Nero stream)					
Oct 1-15		1 Loon (unk)				
		1 Rough-legged Hawk				
		1 Peregrine Falcon				

1: Age indicated if known. Ad=Adult, Juv=Juvenile. (unk) = Species unknown. Bald Eagle observed at Fox 3 July 16-31.
2: Bald Eagle observed at Fox3 July 16-31. No incidental observations for Leslie, 1-Hump and Fox 2.

Table 3.3-18
Characteristics of Lakes Within the Koala Watershed and Birds Observations, May to October 1994

A) Lake Morphometry	Grizzly	Panda	Koala	Kodiak	Blip	Little	Moose	Airstrip
Shoreline Length (km)	4.48	3.82	3.37	8.53	1.33	3.63	4.69	2.40
Lake Length (km)	1.40	1.36	1.25	1.56	0.49	1.11	1.12	0.79
Mean Width (km)	0.42	0.26	0.30	0.58	0.11	0.29	0.34	0.24
Area (km^2)	0.59	0.35	3.37	0.91	0.06	0.32	0.40	0.19
	Larry	**Leslie**	**Long**	**Nero**	**1-Hump**	**Tri-Hump**	**Fox 1**	**Fox 2**
Shoreline Length (km)	2.65	6.81	32.83	14.80	2.18	5.10	4.13	1.59
Lake Length (km)	0.89	2.22	8.43	3.33	0.54	1.22	1.71	0.63
Mean Width (km)	0.26	0.28	0.73	0.40	0.20	0.33	0.25	0.19
Area (km^2)	0.23	0.62	6.14	1.34	0.11	0.41	0.44	0.12
B) Observations	**Number of Birds/km of Shoreline (Number of Species)**							
	Grizzly	**Panda**	**Koala**	**Kodiak**	**Blip**	**Little**	**Moose**	**Airstrip**
Waterfowl Surveys	<1 (1)	2 (3)	4 (3)	4 (6)	0 (0)	2 (3)	3 (7)	0 (0)
Incidental Observations	1 (3)	5 (10)	3 (7)	4 (3)	3 (4)	1 (1)	10 (14)	4 (5)
Total	1 (4)	8 (11)	12 (10)	8 (8)	3 (4)	3 (4)	13 (16)	4 (5)
	Larry	**Leslie**	**Long**	**Nero**	**1-Hump**	**Tri-Hump**	**Fox 1**	**Fox 2**
Waterfowl Surveys	0 (0)	2 (5)	1 (6)	1 (2)	1 (1)	<1 (1)	2 (2)	0 (0)
Incidental Observations	10 (10)	0 (0)	1 (11)	2 (9)	0 (0)	1 (5)	6 (10)	0 (0)
Total	10 (10)	2 (5)	1 (16)	3 (10)	1 (1)	1 (5)	8 (11)	0 (0)

abundance is compared to the length of shoreline, the greatest number of birds per km of shoreline were observed on Moose Lake (13/km), followed by Koala Lake (12/km) and Larry Lake (10/km) (Table 3.3-18). All other lakes had less than 10 birds/km of shoreline. The lakes with the greatest number of birds per km of shoreline also had the greatest amounts of marsh and grassland habitat.

3.3.7.2 Wildlife Study Area

Similar to the Koala watershed, no large waterfowl flocks were observed in the fall during the aerial survey (Table 3.3-19). Ptarmigan were ubiquitous and constituted the largest flocks. The ground checks of lakes included Short-eared Owls, an Arctic Tern and Oldsquaw, species which are difficult to observe from a helicopter.

Table 3.3-19
Waterfowl Surveys of Regional Study Area,
September 13 to 16 1994

	Waterfowl	
Watersheds	**Aerial Survey**	**Ground Checks**
Koala	3 Loon 2 White-fronted Geese 4 Gull 3 Ptarmigan	
Exeter	4 Tundra Swan (1 Ad, 3 Juv)[1]	
Ursula	5 White-fronted Geese	7 Snow Geese 1 Gull 2 Short-eared Owl 3 Ptarmigan
North Lac de Gras	2 Bald Eagle 1 Rough-legged Hawk 14 Ptarmigan	
Paul, Mini and South	1 Gull	2 Loon 5 Canada Geese 1 Gull 1 Arctic Tern 25 Ptarmigan
Lac du Sauvage	1 Gull 11 Ptarmigan 3 Tundra Swan (Ad)	18 Oldsquaw 36 Ptarmigan

1: Age indicated if known: Ad=Adult, Juv=Juvenile. Shoreline lengths of eight lakes surveyed during ground checks total 35 km.

Incidental sightings outside the Koala watershed were biased to the Lac du Sauvage watershed (Table 3.3-20), largely because of the effort placed on documenting wildlife use of the Lac du Sauvage esker. Species composition did not differ inside and outside the Koala watershed.

No waterfowl or shorebirds were sighted on the proposed haul road to Misery Lake during the regional survey. The random lake check of the south end of Paul Lake resulted in two loons, five Canada Geese, one Arctic Tern, 15 Ptarmigan and one Herring Gull, on the lake or on the shoreline.

The shoreline of Misery Lake is rocky with no vegetation. No birds were seen on the lake or shoreline during fisheries work in August and September. No incidental observations were made at Misery Lake.

Table 3.3-20
Incidental Sightings of Birds in Watersheds Other than Koala
(July to October 1994)[1]

Watershed	Jul 1-15	Jul 15-31	Aug 15-31	Sep 1-15	Sep 16-31	Oct 1-15
Exeter			1 Bald Eagle 1 Eagle (unk)	1 Hawk (unk)		
Ursula	1 American Tree Sparrow 14 Lapland Longspur	2 Loon (unk) 1 Rough-legged Hawk		10 Red-breasted Merganser		
Paul & Mini	1 Lesser Golden Plover 1 Least Sandpiper 4 Red-necked Phalarope			1 Eagle 1 Hawk (unk)	7 Red-breasted Merganser 3 Duck (unk) 2 Rough-legged hawk 1 Golden Eagle 1 Hawk (unk)	
Lac du Sauvage	1 Loon 1 Greater Scaup 3 Lesser Golden Plover 1 Parasitic Jaeger 5 Long-tailed Jaeger 2 Arctic Tern 4 Gull 4 Bald Eagle 3 Horned Lark 2 American Pipet 2 American Tree Sparrow 2 Savannah Sparrow 2 White-crowned Sparrow 2 Harris' Sparrow 9 Lapland Longspur 2 Common Redpoll	3 Loon 3 Gull 2 Rough-legged Hawk 3 Golden Eagle 4 Peregrine 1 Short-eared Owl	9 Canada Geese 1 Rough-legged Hawk	50 Canada Geese 5 Snow Geese 5 White-fronted Geese 3 Bald Eagle 2 Rough-legged hawk 3 Peregrine 1 Short-eared Owl	4 Bald Eagle 4 Rough-legged Hawk	1 Bald Eagle

1: (unk) = Species unknown.

3.3.7.3 Future Plans

More than one year's data are required to describe bird presence and habitat use because of natural yearly and seasonal variation in population size. Ongoing studies will complete the species lists initiated in 1994. Bird field surveys to be conducted during 1995 include spring migratory waterfowl, nesting shorebirds, passerine breeding birds and raptors.

3.3.8 Important Wildlife Habitats: Eskers

Eskers, a prominent feature in the tundra landscape, are important wildlife habitats. Barren-ground caribou use eskers for travel, escape from insects in the summer and for feeding on south-facing slopes in the spring. Grizzly bears, wolves and foxes use eskers and other glacio-fluvial deposits to excavate their dens. Wolves also use eskers as vantage viewing points for hunting caribou. Ground squirrels, an important food source for many carnivorous mammals and birds, establish their burrows in eskers.

Eskers are considered a valued ecosystem component because of their importance for wildlife. The scarcity of gravel and other granular materials on the tundra also make eskers valuable as potential quarry sites for road building and other construction material.

The objective of the esker assessment was to describe the eskers available to wildlife at Lac de Gras and to assess their importance. Specific characteristics of dens used by grizzly bears and furbearers are discussed under those separate sections.

Six eskers ranging in length from 7.5 km to 29.5 km within the Lac de Gras project area were surveyed. One discontinuous esker totalling 2.0 km was also surveyed. Of the dens located, there were ten confirmed and ten possible grizzly bear dens, 11 fox (arctic and red) dens and four wolf dens.

3.3.8.1 Previous Research

The first quantitative research on the use of eskers by wildlife in the Northwest Territories was conducted by the Department of Renewable Resources in the summer of 1994 (Meuller 1995). The objective of this research was to quantify the characteristics of carnivore dens and ground squirrel burrows. The particle size of esker materials at den sites was smaller than at adjacent control and random control sites. Slopes at bear dens were steeper than at all other sites. Dens of bears and squirrels tended to be on southern slopes, as found in the Proponent’s studies. Percentage shrub cover was relatively high at bear dens and percentage cover of grass, sedge and fireweed (*Epilobium* sp.) was relatively high at wolf dens. Vegetation biomass at wolf and fox dens and at ground squirrel burrows was relatively high, resulting from repeated activities over time. The vegetation at bear dens showed no alteration.

3.3.8.2 Methods

Eskers were located during wildlife surveys and by examining 1:20,000 colour air photos. Esker assessment involved flying over the eskers at slow speeds and low altitudes to document possible den sites, followed by ground surveys. Numbers, locations and characteristics of wildlife feeding sign, ground squirrel burrows and carnivore dens were recorded.

3.3.8.3 Esker Characteristics

Major eskers within the Lac de Gras area ranged in length from 7.5 km to 29.5 km. The largest esker, at 29.5 km, was the Lac du Sauvage esker, which had the greatest number of carnivore dens: five grizzly bear, three fox and two wolf dens (Table 3.3-21). This esker is part of a larger esker trunk that extends north-west and traverses the Lac de Gras area.

Table 3.3-21
Carnivore and Ground Squirrel Dens in Eskers, 1994

Esker	Length of Esker (km)	Ground Squirrels Burrows / km				Carnivores	
		N (E)	S (W)	Top	Total	Dens/km (# dens)	Den Types[1]
N. Lac de Gras[2]	2.0					1.0 (2)	2 Fox
Fish Lakes	7.5	4.9	19.9	0.1	24.9	0.4 (3)	Bear, Bear(P), Fox
Exeter Lake	7.7	10.1	10.4	0	20.5	0.8 (6)	4 Bear(P), 2 Fox
Ursula Lake (East)	9.0	19.2	21.5	4.4	45.1	0.1 (1)	Wolf
South of Ursula[2]	11.3					0.4 (5)	Wolf, Bear(P), 3 Fox
Ursula Lake (West)	12.7	4.3	8.9	2.5	15.7	0.4 (5)	3 Bear, 2 Bear(P)
Lac du Sauvage[2]	29.5	11.6	11.6	12.2	35.4	0.3 (10)	4 Bear, 1 Bear(P), 3 Fox, 2 Wolf
Total	**79.7**					**0.4 (32)**	**8 Bear, 9 Bear(P), 11 Fox, 4 Wolf**

1: (P) = Possible den.
2: Ground squirrel burrows not enumerated for North Lac de Gras and South of Ursula Eskers and only to km 22.5 of Lac du Sauvage Esker because of snow accumulation.

Characteristics other than the length of an esker were important in determining whether carnivores used the esker for denning. For example, the North Lac de Gras esker is small, totalling no more than 2 km in length. It had two fox dens for a density of 1 den/km, the greatest density of all the eskers. Conversely, the Ursula Lake East esker, which is 9 km in length, only had one carnivore den (Table 3.3-21).

Ground squirrels established burrows in all eskers and wherever the substrate provided suitable cover. This species was not necessarily dependent on eskers or other glacial deposits. Burrows were also observed off-esker, where boulders provided overhead cover.

Although there were differences among eskers, ground squirrels seemed to prefer slopes to esker tops for their burrows, and south- or west-facing slopes (Table 3.3-21). The Ursula Lake east esker had the greatest density of ground squirrel burrows, 45.2 per km, followed by Lac du Sauvage with 35.5 burrows per km. All others eskers had burrow densities under 25 per km.

3.3.8.4 Future Plans

Future plans are for a continuation of the field work initiated in 1994. Eskers and accumulations of glacio-fluvial material not assessed in 1994 will be surveyed in 1995. Use of eskers and dens by wildlife will be monitored.

3.3.9 Important Wildlife Habitats: Riparian and Wetlands

The terms riparian and wetland sometimes are used to refer to the same types of habitat; however, there are differences. Riparian refers to habitats adjacent to permanently flowing or intermittent waterways and drainages (Ohmart and Anderson 1986). Drainages need not flow for many years but they still represent riparian communities if plant species along these drainages are different from those of adjacent habitats. Riparian ecosystems are fed and dependent on watersheds; thus a healthy watershed indicates a healthy riparian system. Conversely, the destruction of a riparian ecosystem also means that the watershed has been damaged. Nutrients, water and detritus are transported into the riparian system from its watershed. Degraded watersheds produce high surface runoff carrying valuable soils into the stream, reducing productivity of both the aquatic and terrestrial portions of the system (Ohmart and Anderson 1986).

Wetlands, also called marshes, are shallow water bodies characterized by hydric soils and water-loving plants. They tend to be found in shallow basins and are often complete entities. Wetlands are comprised primarily of emergent vegetation communities (Weller 1986). They are not static habitat types but extremely dynamic due to the variability in water cycles. The variable nature of wetlands make them essential in nutrient recycling (Weller 1986). Marshes also have important roles in damping floods, in water purification and in water recharge (Weller 1986).

Compared to upland habitats, wherever they occur in North America riparian and wetland habitats are very limited and highly valuable for wildlife and for ecosystem functioning (Weller 1986). Within the Lac de Gras area, in association with eskers these habitats are important for wildlife. Their importance merits considering riparian and wetland habitats as a valued ecosystem component.

Attention on riparian and wetland habitats during 1994 was focused on the mapping and classification of vegetation communities, primarily from air photos. Little riparian or marsh habitat is found adjacent to the camp site and the lakes to be dewatered; however, this limited habitat will be important to wildlife species that do use the area and, wherever possible, these habitats will be protected.

Future research will determine the distribution of riparian and wetland habitats in the Lac de Gras area, describe community characteristics such as size and species composition and assess any effects of project development.

3.3.9.1 Previous Research

Not including coastal arctic habitats, vegetation communities of the Southern Arctic Ecozone have not been classified and mapped. There is little understanding of the distribution and composition of plant species within riparian and wetland habitats and how these ecosystems change over time, within a season and from year to year. There has been much attention, however, on these habitats elsewhere in North America (Ohmart and Anderson 1986; Weller 1986).

Riparian Habitat

Riparian habitats provide three important life requisites for wildlife species: food, water and cover. Riparian vegetation adjacent to streams and rivers is important as an energy source for aquatic organisms, including fish (Culpin 1986). Such vegetation also provides shade over small-order streams and serves to stabilize banks in preventing excessive sedimentation (Ohmart and Anderson 1986). Cover is an essential component governing how many wildlife species use habitats. In the absence of trees, vegetation communities that provide cover are critically important. Overhead cover provides protection from extremes in weather and from predators. Horizontal and ground cover provide structural diversity for denning and for nesting. Cover can hide a prey from its predator or a hunting predator from its prey. Willows (*Salix* spp.), a common component of tall shrub communities at Lac de Gras, are obligate, or riparian-dependent shrub species (Ohmart and Anderson 1986).

A number of vertebrates are obligate to riparian ecosystems, meaning they do not occur elsewhere. Throughout North America, some of the highest densities of breeding birds nest in riparian habitats (Ohmart and Anderson 1986). Riparian habitats are important for small mammals such as mice, voles and hares. These communities are used by birds of prey to hunt these same small mammals. Wolves use the cover provided by riparian communities to hunt caribou. Grizzly bears use the same cover for security from other grizzlies and from humans.

Wetlands

The availability of water, diverse plants and rich invertebrate life make marshes ideal for many wildlife and fish species. Concentrated nutrients produce high primary productivity in plants. The secondary production of invertebrates produces an array of potential food exceeded in few if any habitats (Weller 1986). The presence of fish species will depend on the size of the marsh and the permanence of water (Weller 1986). An association with streams may contribute to the presence of fish. The occurrence of fish species within wetlands at Lac de Gras is unknown. The assessment and classification of wetlands during the habitat mapping to be conducted in 1995 will assist in predicting if any maintain fish.

The major herbivores in marshes are mammals such as muskrats (*Ondatra zibethicus*) that not only eat the leaves and tubers of various emergent plants but also build lodges for winter. Muskrats are found at Lac de Gras, as one fresh track was observed during the summer of 1994. Muskrats are a species typically associated with marshes in forested habitat or with extensive marsh habitat above treeline and their distribution and abundance at Lac de Gras is unknown. Future assessment will determine occurrence in the local and regional study areas.

Wetlands are used throughout the snow free season by migratory waterfowl, for feeding, breeding, nesting and for the security cover that the vegetation provides. Wetlands also constitute important spring feeding habitat for grizzly bears and fall feeding habitat for caribou.

3.3.9.2 The Koala Watershed

There is little riparian and no marsh habitat adjacent to Koala Camp and the lakes to be dewatered (Section 3.3.4). The riparian habitat that does exist is along streams, particularly the upper northern reaches of Long Lake. Despite that this habitat is limited in size relative to other areas within the regional study area, it is important to wildlife species that inhabit or pass through the area. Typically these will be bird species and the occasional caribou.

3.3.9.3 Misery Haul Road

An assessment of the value of habitats along the proposed haul road to Misery Lake focused on the riparian and wetland habitats. Relative to other habitats within the regional study area, habitat quality along the proposed route for birds and small mammals was generally poor. The best habitats, riparian communities, are found at five stream crossings. There was also a small wetland prior to the Paul Lake – Lac de Gras crossing. These habitats were limited in size and distribution. However, they are important because they would be used to a greater extent than less productive habitats.

3.3.9.4 Future Studies

Future studies will focus on inventory, mapping, classification and monitoring of riparian, wetland and other habitats. A long-term approach is essential, as one season or even one year is not sufficient to understand or to adequately describe the importance of riparian areas and wetlands. Seasonal and annual variations in wildlife numbers are generally very high and the problem is compounded when such populations occupy variable habitats. The nature of wetland and riparian ecosystems in the Southern Arctic has not been studied and is unknown. The research to be undertaken at Lac de Gras will contribute towards the understanding of these ecosystems.

3.3.9.5 Important Wildlife Habitats: Cliffs

Cliffs are important for nesting by raptors, colonial birds and some passerines. This habitat type is not found within the local study area and is rare within the regional study area. The location and use of cliffs within the regional study area will be determined in 1995.

3.3.10 Summary

Wildlife and wildlife habitat were identified as valued ecosystem components. Two wildlife species, the barren-ground caribou and grizzly bears, as well as one habitat element, eskers, were the focus of most concerns expressed during scoping meetings.

Lac de Gras lies within the migratory pathway of the Bathurst caribou. Field investigations during 1994 attempted to determine the numbers and movement patterns of caribou within the Lac de Gras area, especially the identification of important movement corridors. The proposed mine development area was examined closely. A main migration corridor appears to be along the north shore of Lac de Gras. The maximum number observed in a survey, flown over two days, was 1,330 caribou in the spring, representing less than one-half percent of the total Bathurst herd. Small numbers of caribou grazed within the Lac de Gras area during the summer; no caribou were observed in winter.

Grizzly bears are the most sensitive species within the Lac de Gras area, based on the potential demographic impacts of mortality and habitat displacement. Objectives of field studies were to document sightings and distribution and to obtain preliminary information on food habits. Fourteen observations of grizzlies at Lac de Gras were recorded during 1994. No females with young were observed. Caribou was the most frequent food item in the twelve scats that were collected and analyzed. Other animal foods included arctic ground squirrel, ptarmigan and hares. Ground squirrels were an important food item in the fall. Ten confirmed dens and ten possible grizzly bear dens were located.

Lac de Gras has a low diversity and abundance of furbearers. Foxes and wolverine are found year-round while wolves are only present while caribou are also present. Ermine are also present year-round, but are difficult to see and to inventory. Objectives during 1994 were to document the presence of furbearers at Lac de Gras, to describe preliminary food habits and identify denning locations. Arctic foxes were more common than red foxes. An active fox den was located adjacent to the airstrip at the exploration camp. Seventeen observations of wolves adjacent to the NWT Diamonds project and seventeen observations outside the project area were obtained. Thirteen sightings of wolverine were made. Nine fox dens and six wolf dens were located. Caribou was a prominent prey item in scats of all carnivores. No information on habitat use or food habits was obtained for ermine in 1994.

Small mammals and hares are one component of the biodiversity within the Southern Arctic Ecozone and are important in the arctic food chain, especially when caribou are unavailable. Future studies will determine the occurrence and distribution of small mammals in the project area.

The objective of bird studies undertaken in 1994 was to obtain preliminary information on the occurrence and distribution of species within the Lac de Gras area, particularly within the Koala watershed. Compared to the High Arctic to the north or the Taiga to the south, the bird fauna were low in species abundance and diversity.

Eskers are a prominent feature in the generally flat tundra landscape and are used by wildlife for denning, feeding and travel. The objective of esker assessment was to describe the use of eskers within the regional study area and to assess their importance. Six eskers ranging in length from 7.5 km to 29.5 km were surveyed, plus one discontinuous esker totaling 2.0 km. A total of 32 carnivore dens were located, ten confirmed and ten possible grizzly bear dens, 11 fox (arctic and red) dens and four wolf dens.

Riparian and wetland habitats are valuable for wildlife and play important roles in ecosystem functioning. Habitats were mapped and classified from air photos. Little riparian or marsh habitat exists adjacent to Koala camp and the lakes to be de-watered, Airstrip, Long, Panda, Koala, Leslie, Long and Fox 1.

There is no cliff habitat within the local study area, and it is rare within the wildlife study area. The location and use of cliffs, as well as riparian and wetland habitats, within the wildlife study area will be determined in 1995.

4. Socioeconomic Setting

This section of the NWT Diamonds Project Environmental Impact Statement provides background on the social and economic environment of the Northwest Territories and of the communities that have been or may be affected by the project.

The Northwest Territories is unique in Canada for its majority Aboriginal population, its rich variety of official languages and its short political history. The Territories is heavily reliant on government funding for most activities and services, yet has the potential to become more economically self-reliant.

The territorial economy can be described as two different and not always compatible economies, a traditional economy based on subsistence activities, and a more modern economy based on resource extraction and government. Another feature of the NWT is the relative size of its communities. One city, the territorial capital of Yellowknife, at 17,000 population, is five times larger than the next most economically sophisticated community, Hay River. Yellowknife also has five times the combined population of all the Aboriginal communities included in the study area, which rely to some extent on subsistence hunting and fishing. This presents some difficulties in attempting to compare levels of activity between one community and another, since the economic base is so different.

To assess future impacts of the project, information had to be gathered on the economic and social life of the study area in 1995. The most current population and employment data come from the 1994 NWT Labour Force Survey. The survey also asks a number of questions related to lifestyle. While some detailed data by community are not available, summary data have been used for reference as appropriate. The labour force survey, by itself, does not meet all the needs of a baseline study. Census data from the most recent Census, 1991, filled most needs.

Census data provide the most comprehensive picture of Northern people, but suffer from some omissions as a result of the timing of the Census. These omissions are magnified in the resulting data, as a result of rounding upwards or downwards, to protect privacy or for simplicity. The combined effect of these omissions and adjustments can be misleading when dealing with the social and economic activity in small communities. Various tables received directly from the NWT Bureau of Statistics have population figures that are not always exactly consistent. Population figures from RCMP statistics may also vary from figures from other sources. Unless noted, no attempt has been made to adjust these numbers to obtain exact agreement.

Considerable general knowledge of the NWT and cross referencing were required to determine which census figures could be used to present the baseline fairly. To complete the picture, data were drawn from a number of other sources, including personal communications and community interviews, as noted in the text. Generally, data come from 1991 through 1994 and are the most up to date available. No comprehensive studies by other parties are available for reference, although some studies have been done on employment and mining; these are referenced where used.

Communities Selected for Review

Communities were selected for review on the basis of possible impacts of the project on the community or the potential of the community to supply workers and services to the project. Included are the Treaty 11 and Treaty 8 communities closest to the proposed project site, as well as Coppermine, Yellowknife and Hay River. To a large degree this ability to provide services to the project is dependent on distance (Air Tindi 1995) and communication links with the project site (Figure 4-1). The populations of the study region communities are summarized in Figure 4-2.

The Treaty 8 and Treaty 11 study communities (Section 4.2) are grouped together because their concerns are similar and their economies have many similarities. All are involved in land claims negotiations, all have the potential to supply workers to the project and all have some cultural and specifically Aboriginal concerns regarding employment and other benefits. These communities are the Dogrib Treaty 11 communities of Rae-Edzo, Rae Lakes, Wha Ti and Snare Lake, and the Treaty 8 communities of Dettah, N'dilo and Lutsel K'e. Lutsel K'e was added after the data gathering had started, as a result of interest shown in the project by residents of that community.

Coppermine (Section 4.3) was selected because its Inuit residents have experience over many years with rotational employment and might be expected to seek employment with the project. Coppermine is also the only community in the same water drainage system as the NWT Diamonds Project.

Yellowknife (Section 4.4) is the largest community in the study region. The city is a potential employment base and transshipment point for winter road and air transportation to the site. It is the community likely to benefit most from the project. Yellowknife has been designated as the major "point of hire" for the NWT Diamonds Project.

Hay River (Section 4.5) has been involved in major mining projects for almost 30 years. It served as the supply centre for the Pine Point mine for more than 20 years and now supplies services to Colomac. With its transportation links, its history of involvement in major mineral projects, its relatively skilled work force and its aggressive small businesses, Hay River presents itself as a community with much to gain from the project.

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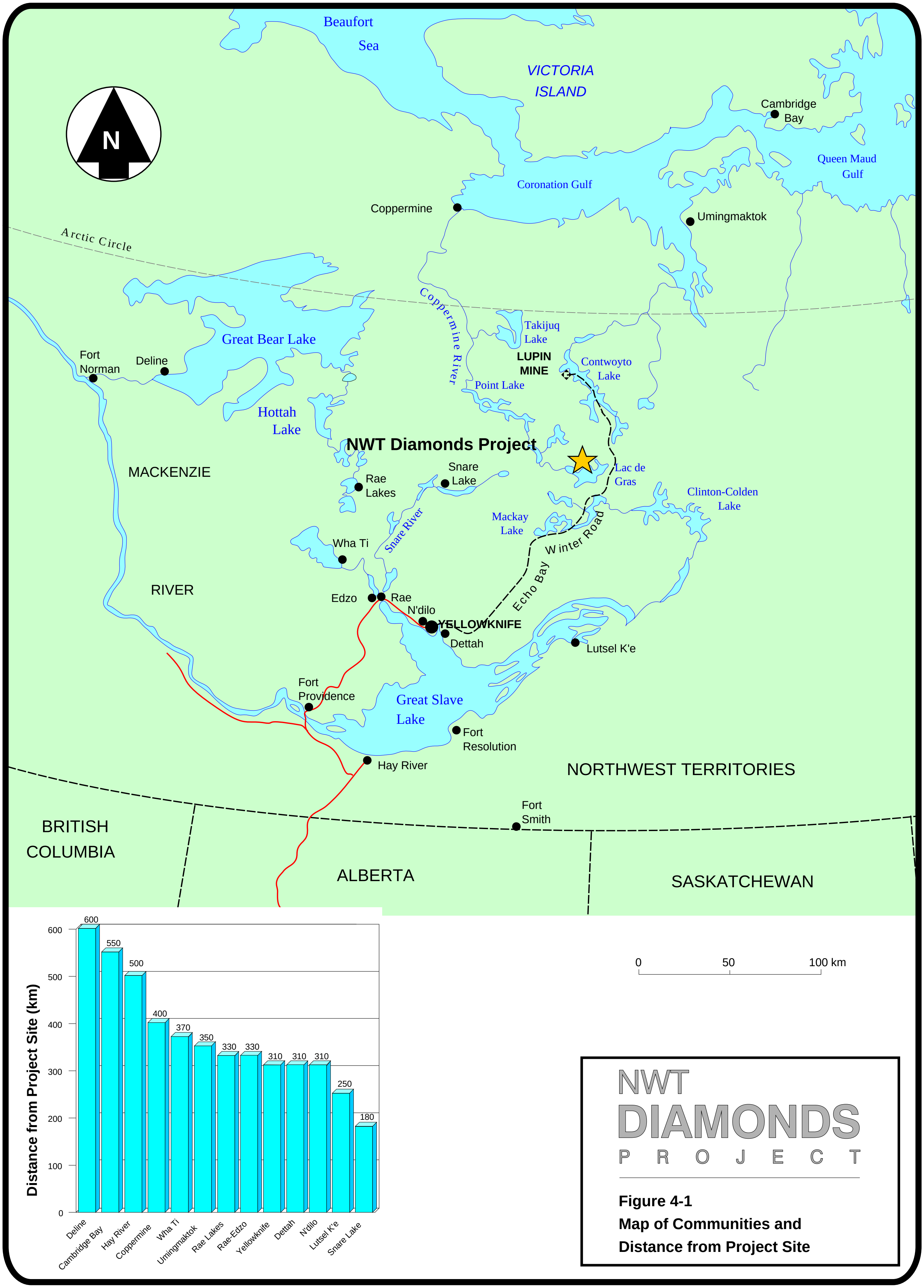

Figure 4-1
Map of Communities and Distance from Project Site

Source: Rescan

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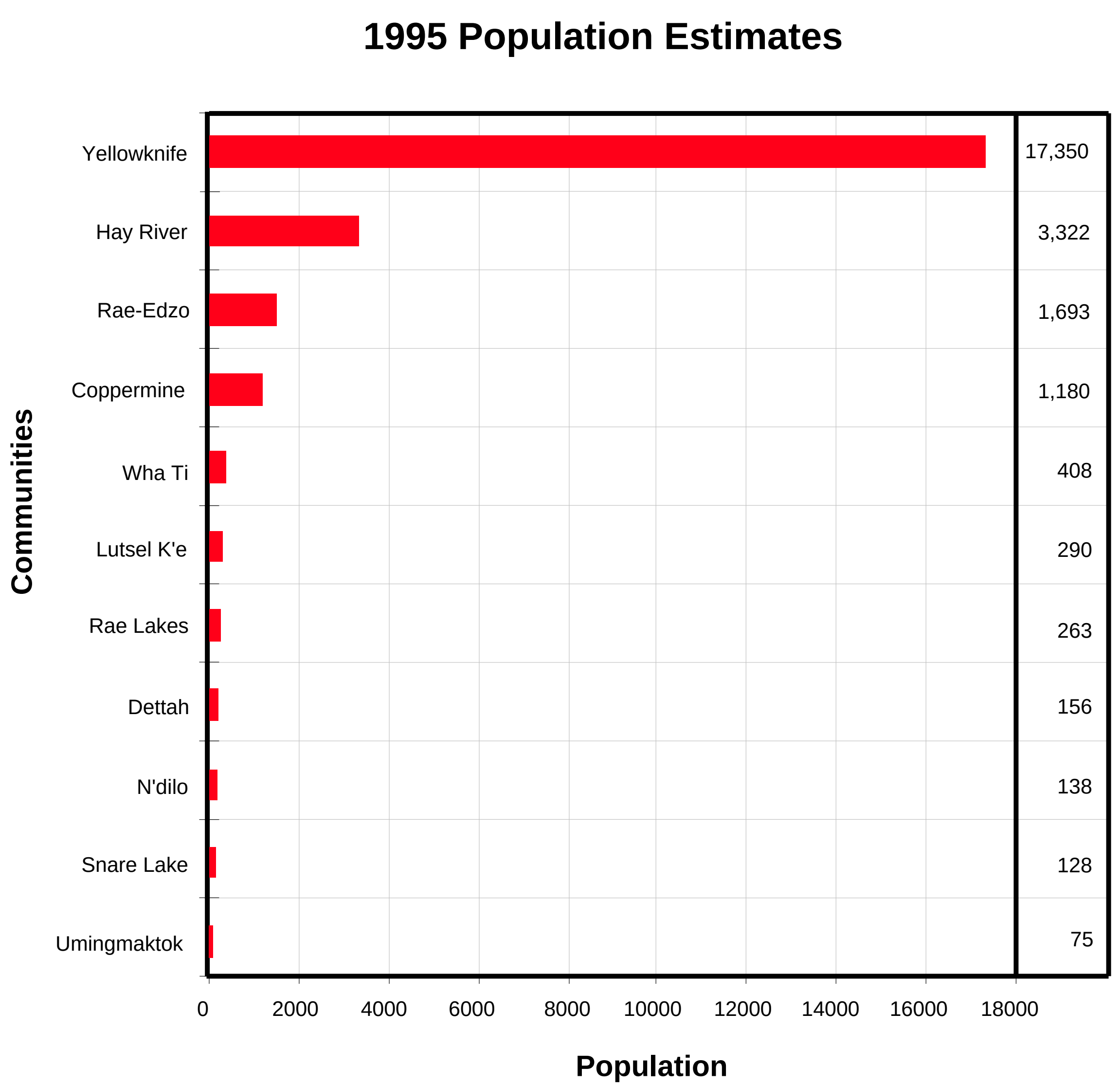

NWT DIAMONDS PROJECT

Figure 4-2
Population of Study Region Communities

Source: Municipal and Community Affairs, Community Estimates, Kingaunmiut Development Corporation, Outcrop

Umingmaktok/Bathurst Inlet, with a combined population of approximately 100 people, was not reviewed in detail.

The assessment also includes an analysis of the Northwest Territories economy. This is a baseline study in itself and provides necessary background on many of the communities noted above (Section 4.1).

4.1 Northwest Territories

The area of Canada called the Northwest Territories is the traditional home of two groups of Aboriginal people, the Dene of the Mackenzie Valley, Great Bear and Great Slave Lake areas, and the Inuit, who live north of the treeline. The first contact between these peoples and Europeans occurred at different times in various areas of the North.

4.1.1 Political Setting

Originally, the Northwest Territories was claimed by Great Britain, then parcelled out to the Hudson's Bay Company and new colonies gaining a foothold in what is now eastern Canada.

When the Dominion of Canada took possession of the area in 1870, the North West Territories included the western half of Quebec, most of northern Ontario, all of Manitoba, Saskatchewan and Alberta, Yukon, the continental Northwest Territories, southern Baffin Island and some other Arctic islands. The first contraction of the North West Territories took place less than a month later, when the province of Manitoba was created from the Red River settlement.

The *North West Territories Act* of 1875 established the legal framework for government, which, with amendments, still stands. The remaining Arctic islands were transferred to Canada and the Territories in 1880. The more populous areas soon formed separate provincial and territorial jurisdictions. The Yukon Territory was created in 1898, and Alberta and Saskatchewan were granted provincial status in 1905. The NWT assumed its present shape in 1912, when the boundaries of Manitoba, Ontario and Quebec were extended northwards to their present limits.

Little attempt was made to manage or use the Northwest Territories until the increasing level of economic activity prompted the federal government to act to protect the rights of Aboriginal people and the crown interest. Treaty 8 was signed with the Dene south of Great Slave Lake in 1899, largely as a result of an influx of prospectors en route to the Yukon goldfields.

The discovery of oil at Norman Wells prompted the signing of Treaty 11 with the Mackenzie Valley Dene. At the same time, the first Territorial Council was appointed. The six senior federal government officials were joined by the Deputy Minister of the Department of the Interior, acting as Commissioner of the NWT.

The Department established offices in the Mackenzie District and pursued field work. The early Government of the Northwest Territories (GNWT) licensed scientists and explorers, regulated fur exports and protected Aboriginal archaeological resources.

Mining developments around Great Bear and Great Slave lakes in the 1930s led to new federal policies. The newcomers who poured into the Mackenzie District brought with them a concern for representative government. The first municipal government in the District was established at Yellowknife in 1940, but it would be another 35 years before an NWT Territorial Council was fully elected.

During and after World War II, Canada and the United States co-operated on several military projects in the NWT, including the construction of several airports still in use today. These projects focused federal government attention on the North, and increased access to and familiarity with the NWT.

Settlements grew up around these military projects, and with them came increased pressure for self government. The *North West Territories Act* was amended to allow elected representation to Territorial Council in 1951. By 1966, elected members outnumbered appointed members. In 1967, the NWT seat of government was moved to Yellowknife from Ottawa and Fort Smith, and a resident territorial administration was established.

In 1970, after three political/constitutional task forces had reported to Honourable Jean Chrétien, then Minister of Indian Affairs and responsible for the North, the federal government began to transfer programs. Education, social assistance, economic development and municipal affairs devolved to the new territorial administration.

By 1975, a fully elected and renamed Legislative Assembly took control and requested further powers. Another review was undertaken. In 1977, a policy paper on political development in the NWT favoured the gradual withdrawal of the federal government from decision making and the transfer of further powers to the territorial government. There was one exception: the federal government intended to maintain control over non-renewable resources. At the time, territorial and national interest was focused on a selection of competing proposals to deliver the oil and gas found in the Beaufort Sea and High Arctic to southern markets via pipelines through the Northwest Territories.

A federal review headed by Justice Thomas Berger held hearings in the Mackenzie Valley on one pipeline proposal. Though the economics at the time seemed favourable and in spite of the fact that the federal government had invested heavily in Beaufort and High Arctic exploration, Justice Berger recommended a 20 year delay. The pipeline projects were shelved, and the companies turned their attention to other projects. Oil and gas exploration was eventually abandoned as well. The projects were halted largely as a result of northern Aboriginal opposition to the development.

The opposition was driven by a demand that Aboriginal land claims should be settled prior to development. Today, several claims have been settled or are in the final negotiation process in the Mackenzie corridor and the eastern Arctic (Volume I, Section 1.4).

At the same time, there has been a tremendous increase in the amount of information available on the non-renewable resources of the Northwest Territories, due to technological improvements in prospecting and mapping. The resources of the NWT, still largely untouched, are drawing increasing interest from the world-wide mining community.

The Government of the Northwest Territories is now devoting considerable energy to finding sources of revenue to support a burgeoning population. At the same time, Aboriginal claimants are also pressing a case for a share of the potential non-renewable resource riches of their traditional lands.

In the 1990s, the federal government is attempting to balance the interests of the country as a whole with the interests of the residents of the North. In the east, this will result in a new territory called Nunavut, in 1999. The future political development of the western part of the Northwest Territories is less clear. The western territory may comprise an unknown number and variety of jurisdictions resulting from the Aboriginal claims process and the evolution of municipal and regional government. Although discussions are cordial, the various parties are still some distance apart on the division of powers. However, all of the internal groups in the North want to share in the benefits from non-renewable resource development.

4.1.2 Geography

The Northwest Territories covers an area of 3.3 million km^2 and constitutes approximately one-third of Canada's land mass. Almost all of this area lies above the 60th parallel, much of it above the Arctic Circle. The landscape includes Precambrian rock, ancient mountain chains and an extension of the Great Plains. Part of the area is forested, and part lies in the treeless region generally described as the barrens, or the Arctic. Due to poor drainage, much of the Northwest Territories is covered in bog or muskeg. The mineral producing areas currently of interest lie largely in the treeless region north of Great Slave Lake and south of the Arctic Coast.

4.1.3 The Traditional Economy

The economy of the NWT is described as a "mixed" or "dual" economy, combining a modern wage economy and a traditional land-based economy. The modern sector is characterized by the use and continuous adoption of advanced technology to maintain a rising per capita output. The traditional economy is based on the seasonal harvesting of renewable resources, where the level of production is partially dependent on the natural population cycles of the harvested species. The two economies co-exist with limited linkages (Stabler 1989). The strongest link is the Aboriginals' use of wages from the modern sector to purchase modern equipment to better participate in traditional activities (Hobart 1981). The ratio, or mix, of the two economies in the NWT is constantly shifting with time as successive generations of Aboriginals have an increasing interest in participating in the modern wage economy.

4.1.4 Emergence of the Mixed Economy

Before the arrival of the Europeans, two major Aboriginal groups inhabited what is today the NWT. The Inuit inhabited the coastal areas and treeless barrens while the Dene inhabited the forested region south of the barrens (Jenness 1964; Usher 1971; Crowe 1974). Both groups developed unique, self-sufficient subsistence economies highly adapted to their environments. This traditional economy was somewhat modified by the fur traders when the Aboriginal people started to harvest for barter in addition to subsistence.

In the 1930s, the collapse of the fur market combined with the substantial reduction in the caribou population created a situation of extreme hardship for the Aboriginal people. With game scarce, the Aboriginal people started to congregate at trading posts where relief rations were available and where some occasional work might be found (Stabler and Howe 1990).

In the 1950s, the Territorial Council enacted a resolution that recognized that real income derived from fur trapping was less than one-third of its pre-war level, and that subsistence was no longer possible. To offset this impact, a request was made to the government of Canada to "stimulate the economic development of the NWT so that alternative means of employment and income can be provided for these people" (Asch, "The Dene Economy," in Watkins).

Universal education was seen as a necessity in preparing Aboriginal people for participation in the wage economy. An important consequence of the education program was resettlement. Aboriginal people were encouraged to abandon a semi-nomadic lifestyle and to move permanently into communities where schools and housing were being built. As more permanent settlements appeared, the government built housing, infrastructure and administrative offices in Yellowknife and also gave assistance to private companies to encourage investment. Transfer payments, old age security and disability payments were introduced to provide support for the Aboriginal society. All of these programs tended to reduce the Aboriginals' dependence on traditional systems and gradually to move the NWT to a wage based economy.

4.1.5 The Current Economy

As government employment in the NWT expanded and as the Aboriginal population gained education and became proficient in English, Aboriginal participation in the modern economy accelerated. By 1970, Aboriginal employment in full time jobs accounted for approximately 13% of the potential labour force and Aboriginals with part time employment accounted for an additional 20%. Another 9% were self-employed, either full or part time (Table 4.1-1).

Table 4.1-1
Aboriginal Employment in the NWT
1969-1971

		Inuit	Dene	Metis	Total
Total Pop. 15-65		5,323	2,913	648	8,884
Employed (Wages)					
	46-52 weeks	712	259	174	1,145
	32-45 weeks	169	70	30	269
	18-31 weeks	324	130	24	478
	4-17 weeks	485	307	23	815
	1-3 weeks	154	60	2	216
		1,844	**826**	**253**	**2,923**
Self-employed					
	46-52 weeks	108	8	6	122
	32-45 weeks	48	4	-	52
	18-31 weeks	119	3	4	126
	4-17 weeks	334	8	3	345
	1-3 weeks	129	3	-	132
		738	**26**	**13**	**777**
Hunting-Fishing-Trapping					
	46-52 weeks	211	155	11	377
	32-45 weeks	191	28	4	223
	18-31 weeks	293	89	8	390
	4-17 weeks	224	135	6	365
	1-3 weeks	46	11	2	59
		965	**418**	**31**	**1,414**

Source: Sheila Meldrum and Marion Helman (1975), Summary of the Statistical Data from the DIAND Northern Manpower Survey Program in the Yukon and NWT, 1969-1971 (Ottawa: DIAND).

Since the 1970s, the importance of wages to the Aboriginal people has increased while income from trapping has fallen. As of 1990, only 1,400 Aboriginal people (16% of the Aboriginal population) were engaged in traditional activities with the objective of selling their products for gain (not subsistence), and fewer than 400 of these people participated in traditional activities on a year-round basis (Stabler and Howe 1990).

A 1984 Labour Force Survey conducted by the NWT Bureau of Statistics provides the most recent comprehensive information on Aboriginal employment. Table 4.1-2 indicates that, at the time of the survey, there were 16,299 Aboriginal people between the ages of 15 and 64. Of this total, 10,472 had worked in the modern economy whether full or part time during 1984, a rate over 50% higher than that observed in 1970. It is interesting to note that 38% of Aboriginal people employed at the time of the 1984 survey held jobs in professional, managerial or highly skilled occupations (Stabler 1989). Most trappers, and all those participating in other traditional pursuits, were also engaged in subsistence harvesting. Thus, while employment in the modern economy has come to be the dominant mode of productive activity for Aboriginal people, the traditional economy, especially the subsistence component, remains of considerable importance.

Table 4.1-2
Activity Patterns of Aboriginal People in the NWT
1984

Population 15-64 years	16,299
Employed at Time of Survey[1]	6,132
Worked During 1984	10,472
Engaged in Traditional Pursuits	
Total	6,548
Year-round	1,204
Part Time	5,344
Participants with Jobs	2,349
Commercial trappers	3,191

Source: NWT Labour Force Survey 1984.

1: The Labour Force Survey was taken in January-March, 1984. Thus, the number of employed is less than shown for the 1981 census. However, the census data refers to June 1981. Seasonal patters of some types of jobs reduce employment substantially during the mid-winter months.

Each successive generation has, with increasing intensity, pursued jobs in the modern economy (Stabler 1989). The higher the level of educational achievement, and the more willing one is to relocate within the NWT, the greater the likelihood of obtaining a job (Kuo 1976). Further, even while there is a large, continuing participation in traditional activities, analysis of the labour force survey data clearly reveals that this participation, whether in subsistence harvesting or commercial trapping, declines as the economic opportunity cost of participation increases (Stabler and Howe 1990).

4.1.6 Concerns

Despite the improvements in education, health and housing, however, problems exist. Since housing, schools and other infrastructure were provided in the communities where people were initially assembled in the 1950s – essentially around trading posts – this has frozen the population into a distribution unrelated to considerations of the modern market economy. This distribution has made it easier to continue subsistence harvesting but more difficult to obtain wage employment. Other concerns include levels of educational attainment, which need to rise much higher before Aboriginal people can consider entering job markets in southern Canada in any numbers or could qualify for highly skilled and professional jobs in the NWT. Finally there is still substantial unemployment and underemployment among the Aboriginal population of the NWT. The slowdown in the growth of the economy has, even now, produced a situation in which the rate of growth in employment is less than the rate of growth in the Aboriginal population of labour force age (Stabler and Howe 1990).

Gordon Robertson, a former commissioner of the NWT, remarked at an early stage in the government's development initiative:

"The long-term solution, however, lies in provision of alternative and supplementary livelihoods. This is a complex task. It necessitates initially the provision of extended education and vocational training facilities to enable young natives to prepare themselves for wider employment opportunities. As these opportunities in existing and new industries become more widespread, as educated and trained young people become available, those who wish to enter wage employment should be able to do so..." (Robertson 1955).

Although a substantial effort has been made and many objectives have been realized, Robertson's statement is as valid today as it was in 1955, with one difference. Substantially more Aboriginal people will be hoping to find a job in the next ten years than did so during the decade following Robertson's statement (Stabler and Howe 1990).

The growing interest by the Aboriginal people to participate in the wage economy is clear but the dilemma remains as to how this can be achieved without sacrificing the cultural heritage of a traditional land-based lifestyle.

4.1.7 People/Demographic Profile

Despite the large size of its land mass, the Northwest Territories is relatively unpopulated. The NWT's 64,000 residents (NWT Bureau of Statistics 1993) represent only 0.2% of the Canadian population. The people of the NWT form a multi-ethnic society of Inuit and Inuvialuit (37%), Dene (17%), Metis (7%) and non-aboriginal (39%) (Table 4.1-3). There are nine official languages in the NWT, seven of which are Aboriginal languages. The North is the only jurisdiction in

Canada where Aboriginal people are the majority. Aboriginal people form the largest share of the population, the electorate and the representation in the Legislative Assembly. The population is young and growing at a high rate (Table 4.1-4). About 41% of the population is under 20 years of age, only 3% is over 65 (Table 4.1-5). The birth rate is 25 per 1,000 – about two times the national average (NWT Health 1990a).

Table 4.1-3
NWT Ethnic Composition 1991

Inuit	21,565	37%
Dene	9,647	17%
Metis	4,090	7%
Other	22,347	39%
Total	**57,649**	**100%**

Source: NWT Bureau of Statistics 1995a.

Table 4.1-4
NWT Population Growth

1951	16,000
1961	23,000
1971	34,800
1981	45,700
1991	57,600

Source: NWT Bureau of Statistics 1995a.

4.1.7.1 Education

Relative to the rest of Canada, formal education levels in much of the NWT are very low. Approximately 27% of NWT residents of working age (ages 15 to 64) have less than a grade 9 education (Table 4.1-6) (Canada Census 1991a). This lack of education is of concern to the GNWT, which is attempting to increase the level of NWT employment in a progressively more technologically dependent global economy.

Table 4.1-5
NWT Population by Age and Sex
1991

	Males	Females
All ages	30,055	27,590
0 to 4 years	3,740	3,630
5 to 9 years	3,210	2,975
10 to 14 years	2,725	2,620
15 to 19 years	2,460	2,295
20 to 24 years	2,725	2,655
25 to 29 years	3,070	3,055
30 to 34 years	2,920	2,660
35 to 39 years	2,470	2,155
40 to 44 years	2,110	1,740
45 to 49 years	1,420	1,125
50 to 54 years	1,005	865
55 to 59 years	790	655
60 to 64 years	550	430
65 to 74 years	570	435
75 years and over	295	305

Rounding by Census Canada.
Source: NWT Bureau of Statistics 1995a.

Table 4.1-6
NWT Population 15 Years of Age and Over by
Highest Level of Schooling

Population 15 years and over	38,555
Less than grade 9	10,350
Grades 9 to 13 without secondary certificate	7,360
Grades 9 to 13 with secondary certificate	2,920
Trades certificate or diploma	1,355
Other non-university without certificate	2,835
Other non-university with certificate	7,190
University without degree	2,855
Without certificate	1,265
With certificate	1,585
With degree	3,685

Rounding by Census Canada.
Source: Canada Census 1991a.

4.1.7.2 Employment and Incomes

About 64% of the total population of the NWT, or 37,000 people, were of working age (15 to 64) in mid 1991 (Canada Census 1991a). By 1994, there were over 42,000 people over the age of 15 (NWT Bureau of Statistics 1994a). Approximately 73%, or 31,140 people, were counted in the labour force, either because they were employed or because they were unemployed and actively looking for work (Table 4.1-7).

Table 4.1-7
NWT Employment 1994

	15 Years and Over	Labour Force	Participation Rate	Employed	Unemployed	Unemployed Rate	Want a Job
Northwest Territories	42,476	31,140	73%	25,874	5,266	17%	10,231
Western Region	28,072	21,663	77%	18,456	3,207	15%	5,521
Western Territory Aboriginal	12,052	7,462	62%	5,071	2,391	32%	4,280
Western Territory Non-aboriginal	16,020	14,200	89%	13,385	815	6%	1,241
Fort Smith Region Study Area*	21,723	17,155	79%	15,025	2,130	12%	3,797
Fort Smith Region Aboriginal	7,656	4,745	62%	3,367	1,378	29%	2,634
Fort Smith Region Non-aboriginal	14,067	12,410	88%	11,658	752	6%	1,164

* Note: The Fort Smith Region is part of the Western Region.
Source: NWT Bureau of Statistics 1994a.

Total employment doubled between 1971 and 1991, from 10,600 to more than 20,000, but unemployment also rose, from 4.2% in 1971 to 16% in 1989, and again to 17% at last official count in 1994 (Norecon 1995). The unemployment rate in the NWT has been increasing as a result of two factors: the rapid population growth, and an increasing preference on the part of Aboriginal northerners for employment, as opposed to traditional life on the land.

In small, largely Aboriginal NWT communities, unemployment rates are significantly higher than those in more urban centres. Unemployment rates in smaller communities average 27% compared to 7% in the capital, Yellowknife. If all persons of labour force age wanting a job are included, unemployment rates show a more dramatic disparity, upwards of 40% in smaller communities compared to 11% for urban centres (NWT Bureau of Statistics 1994a).

Using 1991 census population and labour force data, assuming no change in the current participation rate of 73.4% (and ignoring migration and mortality rates), there will be approximately 6,650 more men and women looking for jobs in the year 2001 than there were in 1991, and 10,660 more in 2006 (Norecon 1995) (Table 4.1-8).

Table 4.1-8
Projected Growth in NWT Labour Force*

Age Group	1991	1996	2001	2006
0 to 4	7,365			
5 to 9	6,190	7,365		
10 to 14	5,345	6,190	7,365	
Working Age				
15 to 19	4,755	5,345	6,190	7,365
20 to 24	5,375	4,755	5,345	6,190
25 to 29	6,120	5,375	4,755	5,345
30 to 34	5,575	6,120	5,375	4,755
35 to 39	4,625	5,575	6,120	5,375
40 to 44	3,850	4,625	5,575	6,120
45 to 49	2,545	3,850	4,625	5,575
50 to 54	1,870	2,545	3,850	4,625
55 to 59	1,445	1,870	2,545	3,850
60 to 64	980	1,445	1,870	2,545
Subtotal Working Age	**37,140**	**41,505**	**46,250**	**51,745**
Assumed Participation Rate	73%	73%	73%	73%
Calculated Labour Force	27,112	30,299	33,763	37,774
Increase Over Previous Period		3,186	3,464	4,011
Cumulative Increase			6,650	10,662
% Cumulative Increase		12%	25%	39%

* Ignores migration and mortality rates.
Source: Norecon 1995. Calculations based on 1991 Census data.

Approximately 60% of the job opportunities in the NWT require more than basic education (grade 9). Only 22% of jobs are at the entry level and another 15% require training on the job or some education. Table 4.1-9 gives a breakdown of NWT employment by occupation.

The median personal income in the NWT in 1991 was approximately $26,000 a year, slightly higher than the Canadian average (not taking into account a significantly higher cost of living). However, income distribution is skewed in favour of the larger communities and workers with more education.

Table 4.1-9
NWT Employment by National Occupation Classification, 1994

	Number	Percentage
Management, Skilled Office, Clerical	7,420	29%
Sciences, Health, Education, Government	5,727	22%
Arts, Culture, Recreation, Sport	1,094	4%
Sales and Service	5,968	23%
Trades, Skilled, Semi-skilled	4,669	18%
Processing, Manufacturing	302	1%
Unaccounted	694	3%
Total	**25,874**	**100%**

Source: NWT Bureau of Statistics 1994a.

In communities with populations exceeding 1,000, plus the resource towns of Norman Wells and Nanisivik, the median income was $27,176, based on 1989 average incomes and 1991 populations, whereas median incomes for communities with populations of 500 to 999 and less than 500 were $15,757 and $12,655, respectively. Although these figures are based on 1991 data, they illustrate that incomes in the major centres and resource towns are higher than the national average and considerably higher than incomes in smaller communities. In this case, the lower incomes are a reflection of communities that rely more heavily on the traditional economy (Norecon 1995).

4.1.7.3 Health and Social Profile

The characteristics of the NWT population differ markedly from Canada as a whole. Age distribution, birth rates, fertility rates and death rates all reveal a unique profile.

In Figure 4.1-1, for example, it can be seen that the NWT percentage of young people in each age group is significantly higher than that of Canada as a whole, and the percentage of the population over 30 years of age is significantly lower.

This age differential also shows up in the NWT vital statistics records (Table 4.1-10). In 1989 the birth rate was twice the national average. This high birth rate exceeds population loss through deaths, resulting in the highest "natural increase" of population in Canada. If the rate is maintained, the current NWT population will double by early in the 21st century, with no in-migration (NWT Health 1990a).

Mortality rates due to injury and violence in the NWT are exceptionally high compared to Canada as a whole. This disparity has been attributed to alcohol

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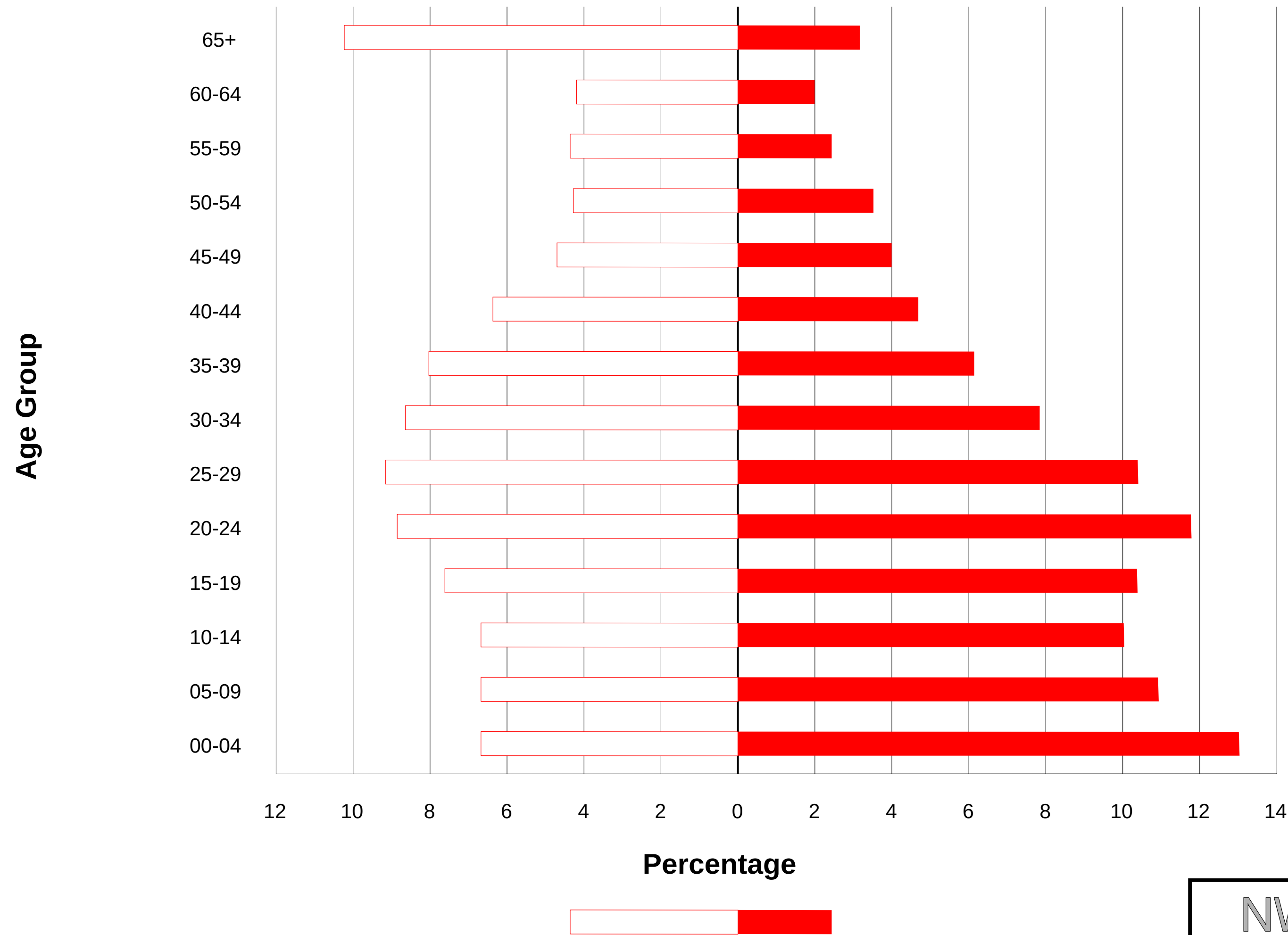

NWT DIAMONDS PROJECT

Figure 4.1-1
Percent of Total Population by Age Group, 1986

Source: NWT Health 1990a

Table 4.1-10
NWT Vital Statistics
1990 to 1993

	Births	Deaths
1990	1,584	227
1991	1,634	237
1992	1,554	256
1993	1,570	268

Source: NWT Bureau of Statistics 1995a.

abuse and the more rugged lifestyle of the North. Violence (accident, suicide and homicide) is the leading cause of death (Table 4.1-11). A particular concern is suicide among young Aboriginal males. In the age group 15 to 24 in the 1980s the NWT rates were five times the Canadian rate (NWT Health 1990a). Communicable diseases are also a concern in the NWT. The rates of gonorrhea in 1989 were between six and 18 times that of the Canadian population. HIV infection is a major concern. Other reportable communicable diseases including tuberculosis, whooping cough and meningitis cause concern from time to time. Large-scale epidemics are now primarily under control due to prompt medical treatment (NWT Health 1990a).

Table 4.1-11
Leading Causes of Death in the NWT
All Deaths During 1988 and 1989

	Females		Males	
Condition	**Number**	**Percentage**	**Number**	**Percentage**
Chronic Obstructive Lung Disease	0	0.0%	17	5.8%
Motor Vehicle Accidents	3	1.9%	16	5.4%
Coronary Heart Disease	3	1.9%	21	7.1%
Homicide	4	2.5%	10	3.4%
Suicide	11	6.9%	40	13.6%
Lung Cancer	12	7.5%	22	7.5%
Other Accidents/Injuries	15	9.4%	36	12.2%
Other Cancers	30	18.8%	41	13.9%
All Other Causes	82	51.3%	91	31.0%
Total	**160**	**100.0%**	**294**	**100.0%**

Source: NWT Health 1990a.

4.1.8 Economic Activity/Sectors

From the 1950s onwards, the economies in most areas of the NWT benefited from various government and industry initiatives. Starting with construction of transportation infrastructure in the mid 1940s, just about every area of the Northwest Territories has received some major investment. Community infrastructure (roads, schools, housing) was put in place in the 1960s and 1970s. A major oil and gas exploration boom in the 1970s provided employment for a time and expansion of transportation services. A pipeline constructed in the 1980s to carry oil from Norman Wells to Alberta provided employment as well. Two mines were opened in the high Arctic in the period, and two opened and closed in the subarctic, creating various impacts on a number of NWT communities.

A very large percentage of investment in the NWT over the past four decades can be attributed directly or indirectly to government spending. This includes investment in infrastructure by the federal government and investment in housing, educational facilities and recreation facilities by the territorial government. Indirectly, the tremendous growth in the number of people employed by government has created investment in airlines and other transportation facilities, as well as a growing service sector.

In spite of this pattern of growth and investment, the NWT today has one of the highest unemployment rates in Canada and one of the lowest per capita incomes. This is despite the fact that the median personal income for employed people in the NWT is slightly higher than the Canadian average.

4.1.8.1 Government

Governments, collectively, are the largest employer in the NWT and the largest purchaser of Northern goods and services. Total public sector employment has risen steadily for 40 years, to 9,629, or 46% of the work force in 1993 (NWT Bureau of Statistics 1995a). Devolution of authority from the federal to the territorial government and from the territorial to municipal governments has led to a redistribution of government employment from major centres to smaller communities over the past decade, providing new jobs in small communities, but increasing their dependence on outside funding (Table 4.1-12).

4.1.8.2 Retail/Accommodation

The NWT has experienced the same shifts in employment opportunities noted elsewhere in Canada. The largest shift has been into the service sector where employment has grown steadily in recent years. Total employment in the retail and accommodation sector in 1991 was estimated at 4,175 (NWT Economic Development and Tourism 1994). A large proportion of these jobs is found in the major centres, including Yellowknife.

Table 4.1-12
Public Sector Employment and Payroll

Year	Number of Employees: Total	Federal	GNWT	Local	Total Payroll ($000)
1993	9,629	1,556	6,572	1,501	421,960
1992	9,437	1,567	6,444	1,426	422,899
1991	9,491	1,563	6,530	1,398	405,193
1990	9,314	1,519	6,410	1,385	382,736
1989	9,002	1,527	6,112	1,363	343,345

Source: NWT Bureau of Statistics 1995a.

4.1.8.3 Tourism

Following a period of growth in the 1980s, tourism visitation slumped in the early 1990s as a result of the world-wide recession, but was beginning to recover in 1993. The major portion of NWT visitors arrive by car (close to 13,000 trips annually) on the road system in the western NWT (Norecon 1995).

Increasing interest in the kinds of natural and cultural attractions the NWT has to offer, as well as demographic trends in the North American population, may provide a boost to NWT tourism in the coming years. The relatively well-off baby boom generation (a third of the U.S. population by the turn of the century according to some estimates) offers significant potential to NWT tourism operators. National trends indicate that outdoor adventure, both of the “soft” or viewing type and the “hard” activity type (hiking, canoeing, climbing, etc.) will become more important for tourism than fishing, hunting and auto touring (Norecon 1995).

4.1.8.4 Transportation/Construction

Both public and private expenditures on construction dropped dramatically between 1989 and 1993 as measured by the decline in the value of building permits (Figure 4.1-2). Private housing investment dropped 35%, from some $31 million to $18 million. Total private capital expenditures on construction plunged 80% between 1989 and 1993, from $473 million to $91 million, marking the end of a construction boom that had been driven largely by pre-recession economic growth in Yellowknife.

Transportation is vital to the NWT economy. Airlines, trucking companies and marine barge services deliver almost all goods for residents of the North. As a result,

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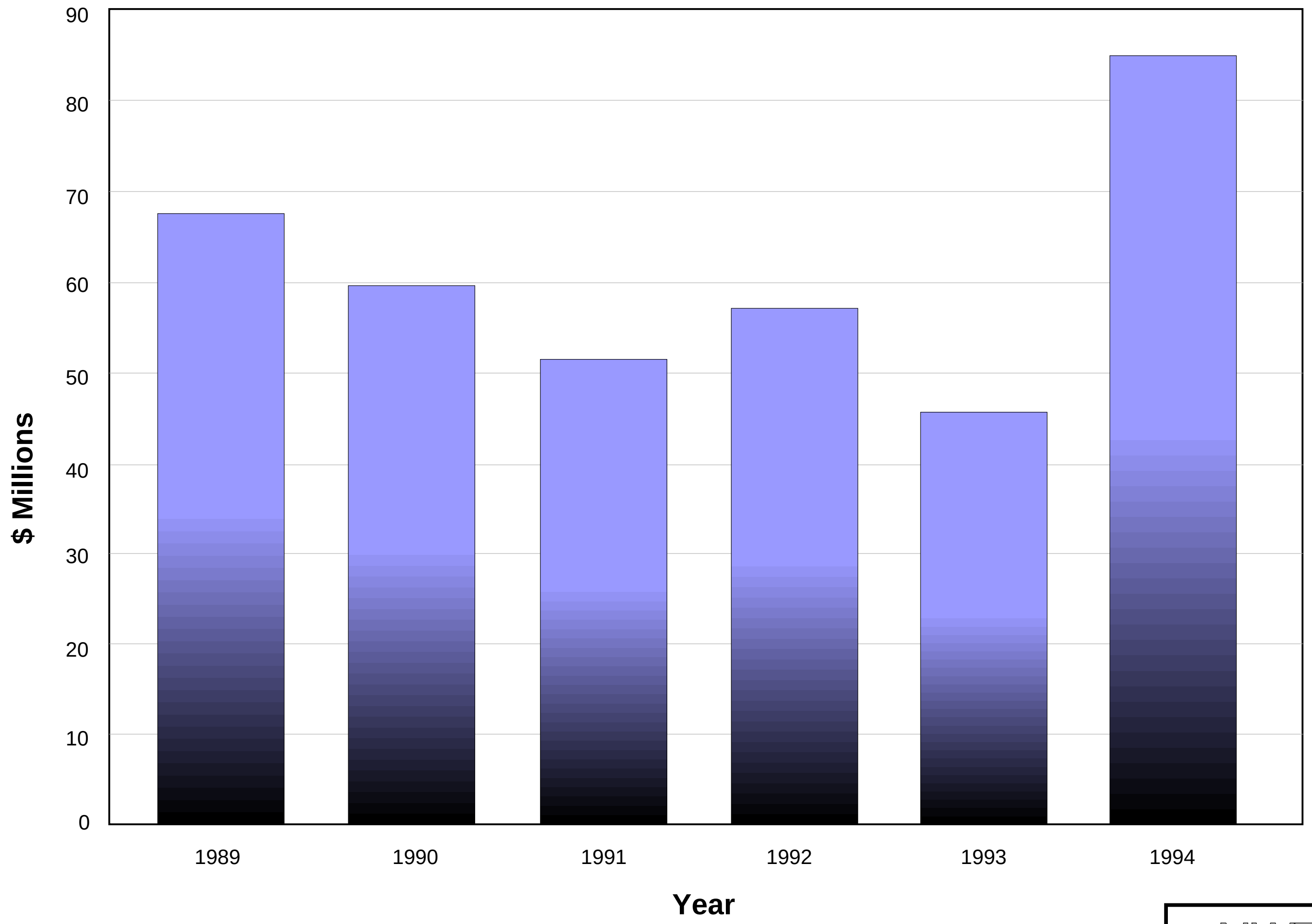

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Figure 4.1-2
Value of Building Permits Issued

Source: NWT Bureau of Statistics 1995 a

many local and territorial businesses have been created in this sector to capture some of the activity in the form of local jobs. After a drop in 1991, the industry maintained its revenues, largely through activity surrounding exploration for diamonds, centred on Yellowknife but spilling over to businesses in Hay River as well. An estimated 1,975 persons worked in the transportation/construction sector in 1991 (NWT Economic Development and Tourism 1994).

4.1.8.5 Mining/Goods Production

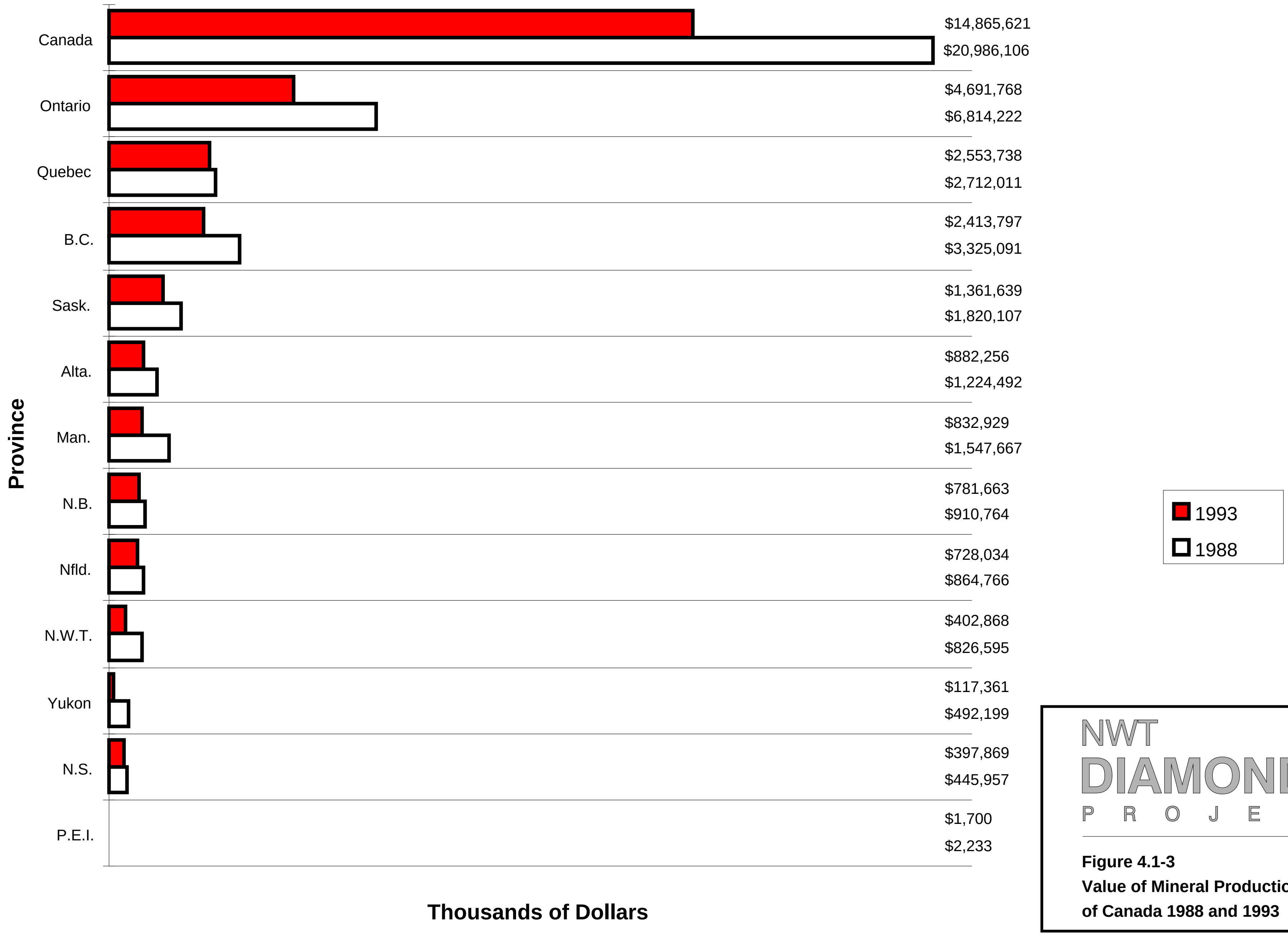
Mining is the NWT's largest revenue generator. A total of seven mines produce about 62% of NWT exports. The total value of metal shipments in the NWT has fallen from a peak of $935 million in 1989 to $389 million in 1993 (Table 4.1-13). The fall in the value of mineral production over this period is largely a function of metal prices, particularly zinc, which suffered a 40% decline in raw material price over this period and of the shutdown of the Pine Point Mine. In the same period, the volume of ore produced at NWT mines has increased, largely due to technological improvements. The NWT has risen to third place in volume of zinc and of lead produced and has maintained its position as Canada's fourth largest producer of gold (NWT Chamber of Mines 1995a). Figure 4.1-3 ranks the value of mineral production by province for the years 1988 and 1993.

Table 4.1-13
Value of Metal Shipments
Northwest Territories
Annual, Thousands of Dollars

		Metals			
	Total	**Gold**	**Zinc**	**Lead**	**Silver**
1993	$389,079	$192,630	$179,760	$14,833	$1,855
1992	468,506	180,501	256,878	28,729	2,397
1991	477,572	223,504	221,464	30,080	2,524
1990	703,833	223,788	420,550	55,766	3,457
1989	934,861	177,260	708,009	41,323	3,820

Source: NWT Bureau of Statistics 1995a.

Mines and exploration companies collectively purchase about $50 million in goods and services annually in the NWT. In 1992, for example, the NWT's operating mines spent $133 million on goods and services (excluding smelting and refining), of which $35.2 million, or 26%, was spent in the NWT (Avery, Cooper 1994a). On the exploration side, NWT businesses captured $11.2 million, or 29%, of the $39.4 million spent in 1992 (Avery, Cooper 1994a). In 1995, over 260 companies, ranging from one person operations to international majors, were listed by the NWT Chamber of Mines as "Exploration Companies Working in the NWT." Only nine listed a NWT address (NWT Chamber of Mines 1995b).



NWT DIAMONDS PROJECT

Figure 4.1-3
Value of Mineral Production of Canada 1988 and 1993

Source: Mining Association of Canada 1993

However, exploration companies have spent an average of $44 million annually on exploration in the NWT over the past five years, reaching a peak of $60 million in 1993 (Norecon 1995).

The increase in mining exploration as a result of the interest in diamonds can be seen in Figures 4.1-4 and 4.1-5. The number of claims in good standing reached a ten-year low in 1991, but by 1993, driven by diamond exploration, had surpassed 1987 levels. The total area staked also reached a new high in 1993.

Excluding mineral exploration, the industry pays more than 1,500 employees (about 7% of NWT employment) more than $100 million in wages annually. Wages in the NWT mining industry average about $65,000, some 30% higher than the Canadian industry average (Norecon 1995).

Depending on gold and other metals prices, and with the possible exception of a small gold mine near Yellowknife, all seven NWT mines are expected to continue operations for at least another five years. Technological change has permitted the mining companies to produce the same output with fewer workers today than 20 years ago.

In the business sector in Canada, manufacturing, at 21%, is the largest single business contributor to the national wealth. Manufacturing contributes less than 2% of the private sector input into the NWT economy. In the NWT, mining and oil and gas production contribute more than 32% of private sector input to territorial wealth, compared to just under 5% nationally.

The NWT Gross Domestic Product (GDP) by industry calculations also reveal that mining and oil and gas production, at 22%, are the second largest contributors to the economy after government spending, at 31%. In Canada, the government contribution to the GDP is a mere 18% of the total, and mining and oil and gas accounted for just under 4% of the total (Figure 4.1-6).

4.1.8.6 Oil and Gas

The NWT produces oil at Norman Wells and gas at Pointed Mountain in the southern NWT (Table 4.1-14). In addition, a small amount of oil is shipped each year from Bent Horn in the High Arctic. Production is increasing; however, revenues are volatile and dependent on world markets.

Esso Resources recently received federal approval to proceed with a $30 million expansion of its Norman Wells oil and gas field. The drilling program will create about 75 person years of work over 18 months and is expected to begin in fall 1995. The result is expected to increase oil production to approximately 1.9 million m^3/a and extend the life of the field to the year 2020.

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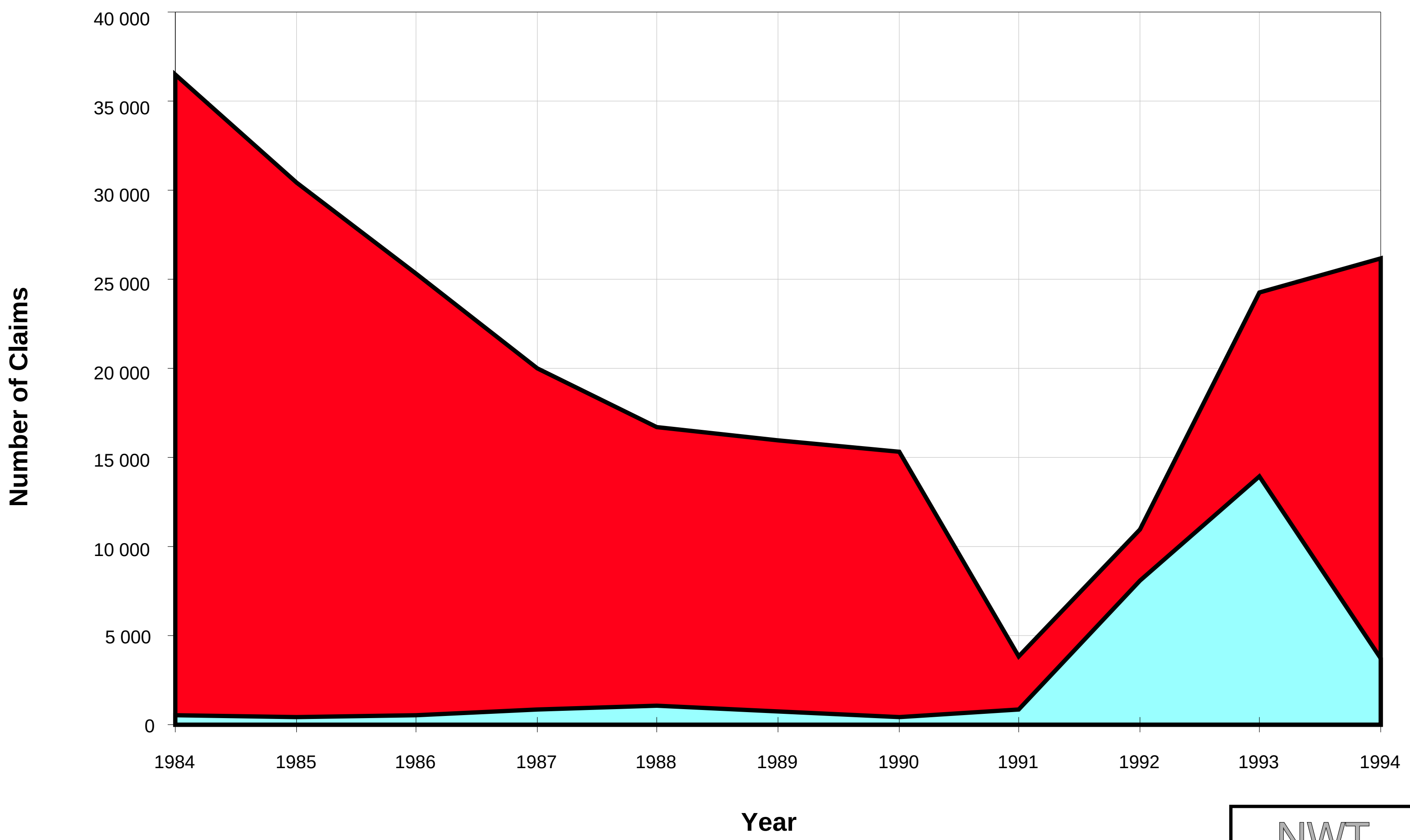

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Figure 4.1-4
Mineral Claims Recorded/
In Good Standing

Source: NWT Bureau of Statistics 1995 a

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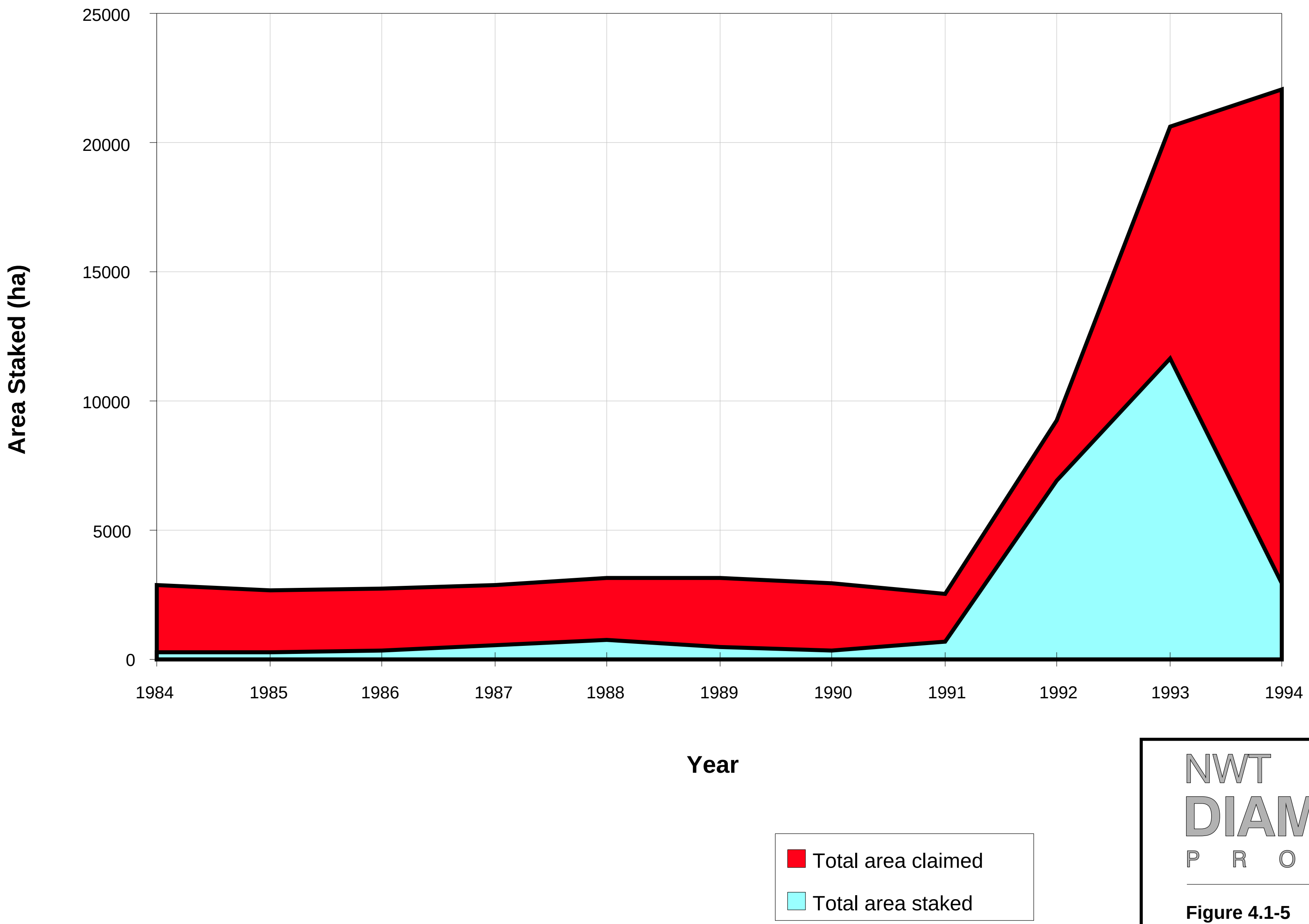

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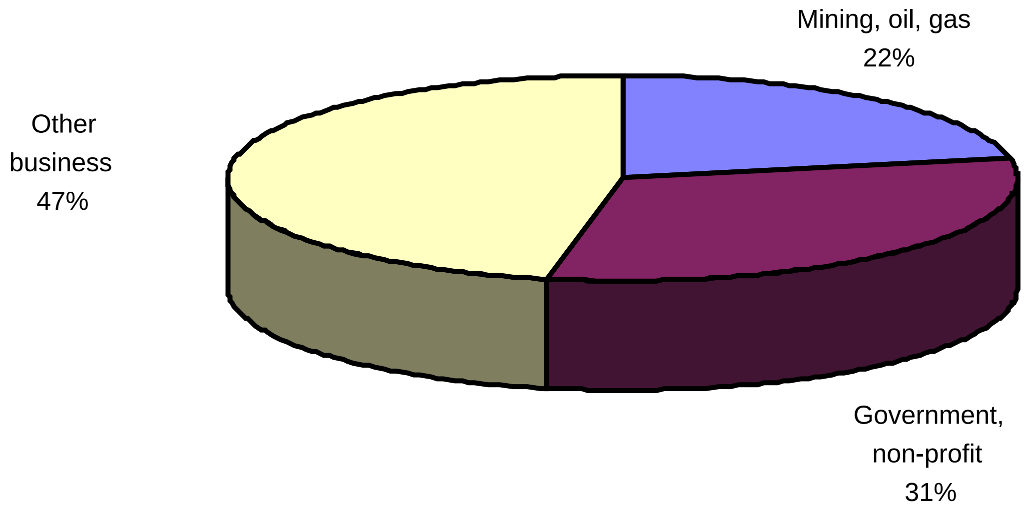
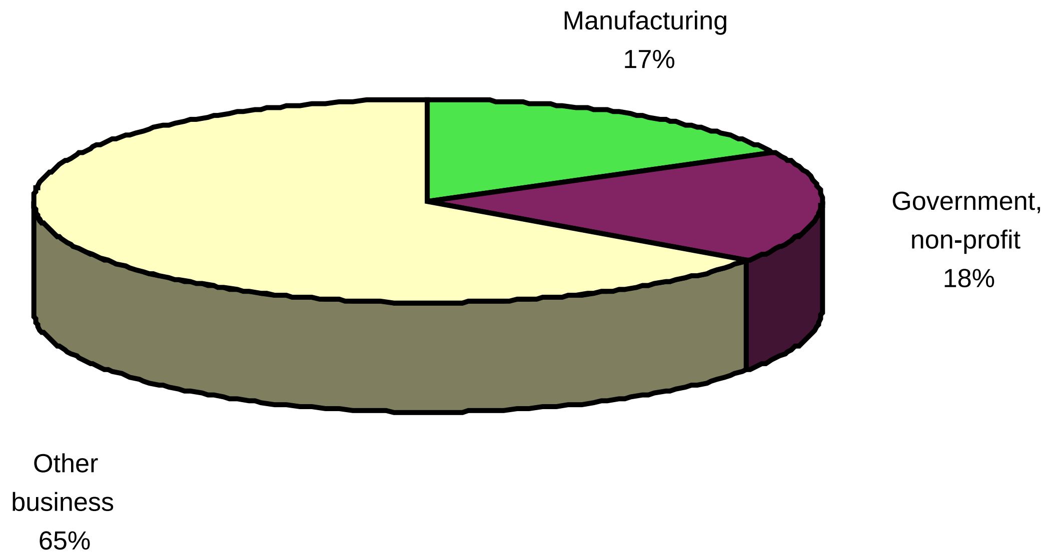
Figure 4.1-5
Mineral Claims by
Area Staked (ha)

Source: NWT Bureau of Statistics 1995 a

NORTHWEST TERRITORIES



CANADA



NWT DIAMONDS PROJECT

Figure 4.1-6
Relative Input to GDP
by Selected Sectors, 1992

Source: NWT Bureau of Statistics 1995a; Mining Association of Canada 1993

Table 4.1-14
NWT Oil and Gas Production

Crude Oil (m^3)		Marketable Gas (1,000 m^3)		
Year	**Norman Wells**	**Norman Wells**	**Pointed Mountain**	**Total**
1994	1,730,807	121,708	50,317	172,025
1993	1,789,541	130,735	79,041	209,775
1992	1,850,379	125,709	66,563	192,272
1991	1,893,515	126,246	68,266	194,512
1990	1,840,514	119,010	59,473	178,483
1989	1,788,586	120,664	74,852	195,516

Source: NWT Bureau of Statistics 1995a.

The world-class petroleum reserves already delineated under the Beaufort Sea are not expected to be developed in the next ten years. However, six petroleum companies are exploring in the Pointed Mountain area near Fort Liard and have pledged to spend some $22.6 million over four years (Norecon 1995).

4.1.8.7 Arts and Crafts

Some 6,000 territorial residents are involved in the production of arts and crafts. Total annual retail sales for some 150 territorial businesses involved in producing, buying or selling arts and crafts is estimated at $28 million, or 2.5% of the Canadian market. Tourists account for 46% of sales across Canada, and collectors account for 24% (Norecon 1995). Arts and crafts production is largely a part time occupation for most workers, and provides a relatively small return to supplement other sources of income. However, a few Northern artists make a very good living from their work, which may be sold as far away as Europe and Japan.

4.1.8.8 Business/Personal Services/Finance

The Business/Personal Services/Finance sector is the largest sector in the NWT in terms of number of businesses; however, many of these businesses have fewer than three employees. The majority of the financial services businesses are located in Yellowknife. This includes five chartered banks and eight financial planning organizations.

There are 23 accounting/bookkeeping firms in major centres and six firms providing office services. Management consultants, architects, engineers and insurance agents also fall into this category. The larger communities also offer many other personal and business services.

In spite of the large number of businesses in the financial field, relative to the population, it continues to be difficult to arrange business financing in many northern communities, and the GNWT acts as banker of last resort with loan programs and outright grants.

Another source of business financing is a growing group of organizations known as development corporations. Often owned by Aboriginal organizations or community groups, the development corporations have taken over the role of business developer in many small communities. Funded by land claims money, Aboriginal business funding and, in some cases, private investors or the NWT government, the development corporations have been able to finance capital projects such as office and apartment buildings in small communities. Development corporations are also involved in transportation, construction and manufacturing businesses.

4.1.8.9 Renewable Resources

Fishing, trapping, forestry and food production employs up to 1,000 NWT residents full and part time.

Fishery

Poor demand has plagued the Great Slave Lake fishery recently, resulting in a 40% drop in revenues in 1993 over 1991 for fish processed through the Freshwater Fish Marketing Corporation in Hay River. The largest NWT fishery is on Great Slave Lake. Fisheries in Baffin reported lower sales of Arctic char, but sales of turbot, harvested in the Davis Strait, increased (Norecon 1995). The total number of jobs in this industry is 200 to 300.

Trapping

Falling domestic and international demand has led to a dramatic reduction in fur production and revenues in the NWT. In 1992/1993, the NWT harvest was at its lowest level since statistics have been kept (Table 4.1-15). In the western Arctic, a cyclical decline in the hare population led to a decline in marten production. Prices for marten have risen, and hare populations are recovering. If trapping activity increases again, some improvement in revenues may be realized (Norecon 1995).

Forestry

The forestry industry in the South Slave has experienced a boom in the past few years. According to Renewable Resources, the industry harvested an estimated 59,884 m^3 of sawlogs (the source of 2 x 4s) in 1993/1994 compared to the previous year's 29,754 m^3. Prices also jumped in the same period, from $40 to $70 per 1 m^3 (Norecon 1995).

Table 4.1-15
NWT Fur Production and Revenues
1990 to 1993

	Pelts	**$**
1989 to 1990	41,335	$2,890,000
1990 to 1991	35,577	$1,853,000
1991 to 1992	38,906	$2,361,000
1992 to 1993	25,541	$943,000

Source: NWT Bureau of Statistics 1995a.

Food Processing and Agriculture

The NWT currently produces about 162,000 kg of pork at Hay River and there is potential for a meat processing plant in that community. Approximately 92,000 kg of caribou and muskox are processed in two plants, one in Cambridge Bay, and one in Rankin Inlet (Table 4.1-16). These operations also processed some 32,000 kg of Arctic char in 1994. Market gardens in Hay River and Norman Wells produce vegetables for the local market.

Table 4.1-16
Commercial Meat Production
1994

Location	**Product**	**Total Weight**
Hay River	Pork	162,000 kg
Rankin Inlet	Caribou	58,000 kg
Cambridge Bay	Caribou/muskox	34,000 kg
Inuvik	Caribou/muskox	49,000 kg
North Slave Study Area	Caribou*	16,000 kg
Total		**319,000 kg**

* Experimental project.
Source: Norecon 1995.

4.1.9 Income and Investment

4.1.9.1 Wages/Employment

Wage earners in the NWT are among the highest paid in Canada as a result of the high wages paid to skilled workers and the high rates paid to a large portion of the work force employed by government at all levels. Of the more than 20,000 full time jobs, some 27% are in public administration (Figure 4.1-7).

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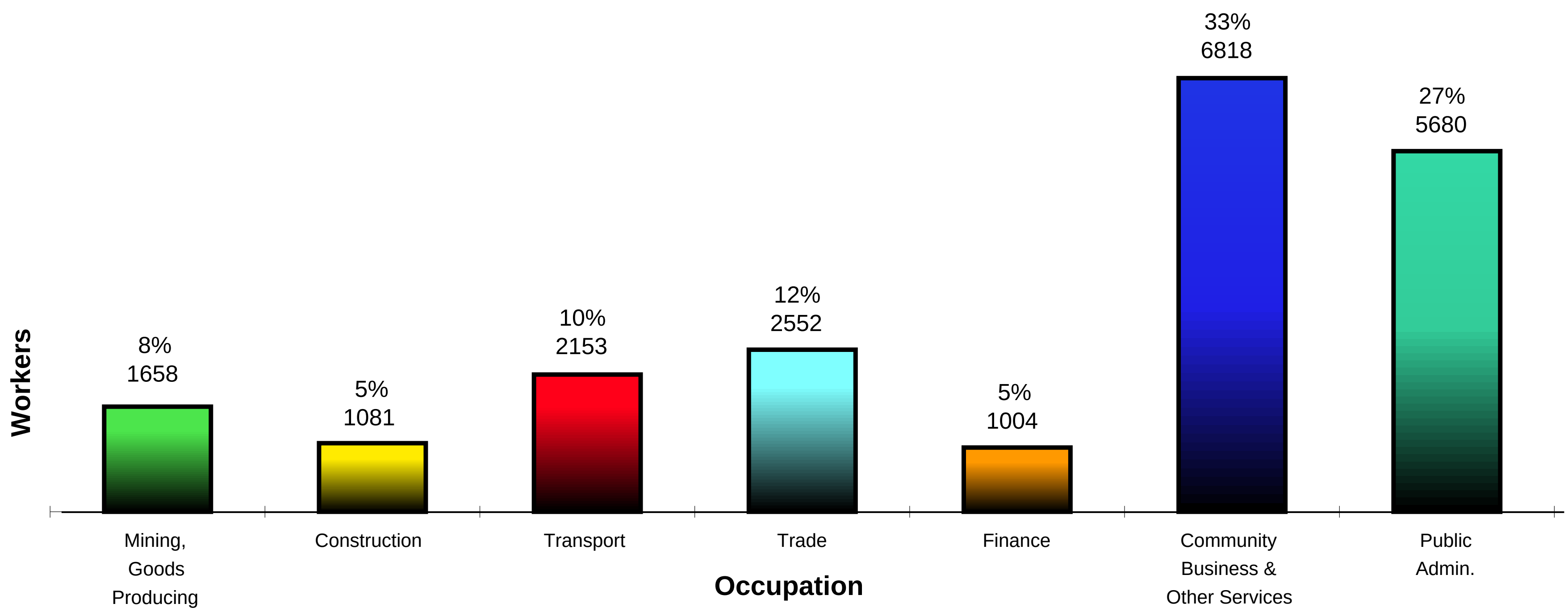

NWT DIAMONDS PROJECT

Figure 4.1-7
Labour Force by Occupation
NWT Employment 1993

Source: NWT Bureau of Statistics 1995a

NWT wage rates in most employment categories are considerably higher than the Canadian average (Figure 4.1-8). Average weekly earnings are also higher than all other jurisdictions (Figure 4.1-9). If all labour force participants wanting employment were employed in the NWT, even at the lowest wage levels, NWT residents on average would be very prosperous. However, lack of education and lack of opportunities in the smaller communities have led to unemployment rates of 30% and more in some areas.

Transfers to persons, including social assistance and unemployment insurance, as a percentage of personal income have grown from 12% in 1986 to 15% in 1993. Although total employment and average income have increased, a greater proportion of residents of the NWT are depending on transfers to make ends meet (Table 4.1-17).

Table 4.1-17
Northwest Territories Sources and Disposition of Personal Income

Annual, Millions of Dollars	**1993**	**1986**
Wages, Salaries	1,024	611
Income from Unincorporated Business and Rent	44	33
Investment Income	78	51
Transfers to Persons	201	94
Total Personal Income	1,347	789
Less Taxes/Other Transfers	<351>	<208>
Personal Disposable Income	**996**	**581**
Total Full Time Employment	**20,946**	**18,971**

Source: NWT Bureau of Statistics 1995a.

4.1.9.2 Income Support Programs

A significant number of people in the NWT depend on income support programs at some time during the year, and payments have been increasing over the years.

Over 54% of adults with less than a grade 9 education and over 35% of young people received social assistance at some time in 1992. From 1982 to 1992, social assistance payments increased from $8 million to $30 million. In the same time period, unemployment insurance payments increased from $7 million to $36.5 million (Table 4.1-18) (NWT Education, Culture and Employment 1994).

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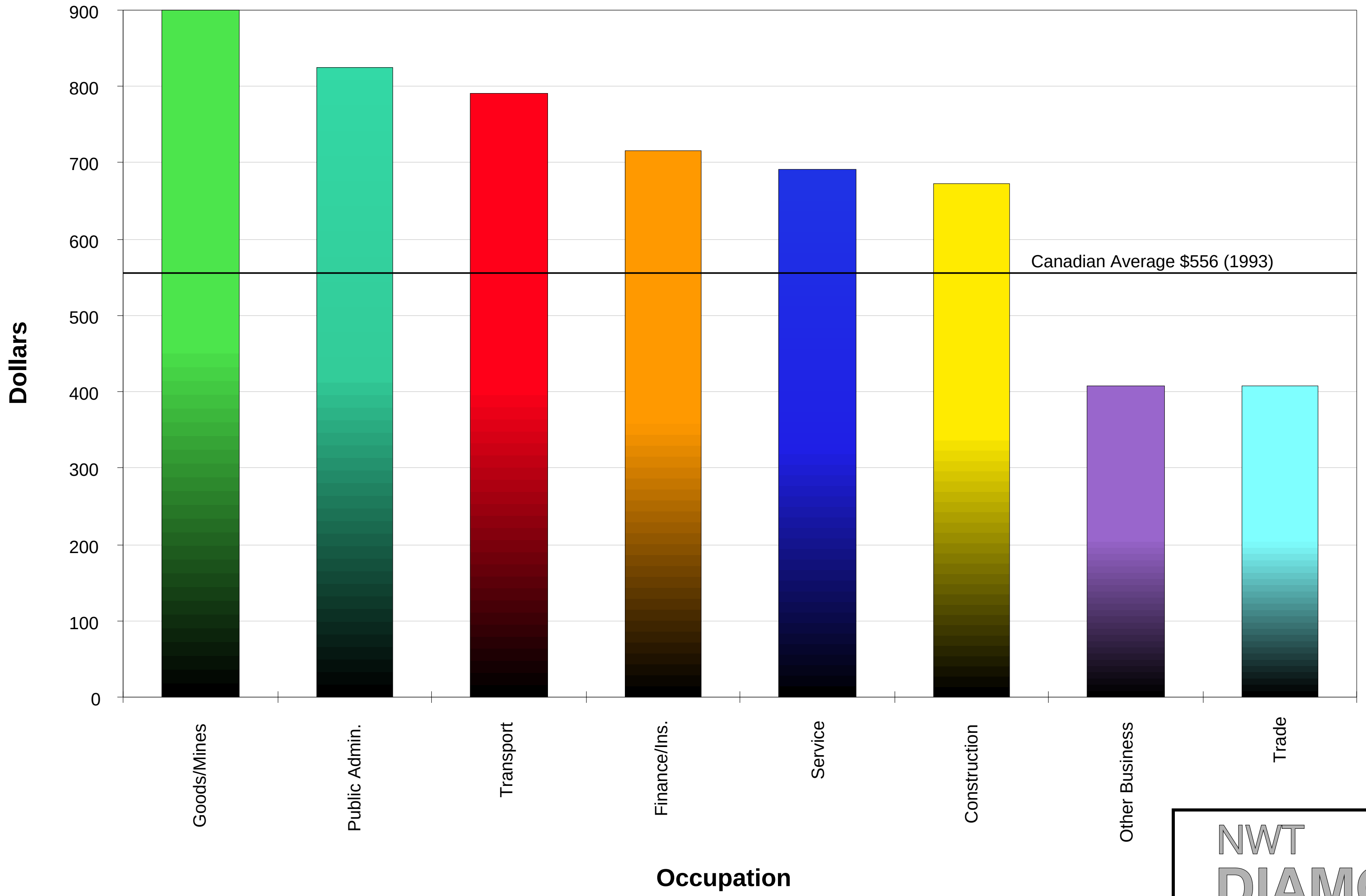

NWT DIAMONDS PROJECT

Figure 4.1-8
NWT Average Weekly Earnings, 1993

Source: NWT Bureau of Statistics 1995a

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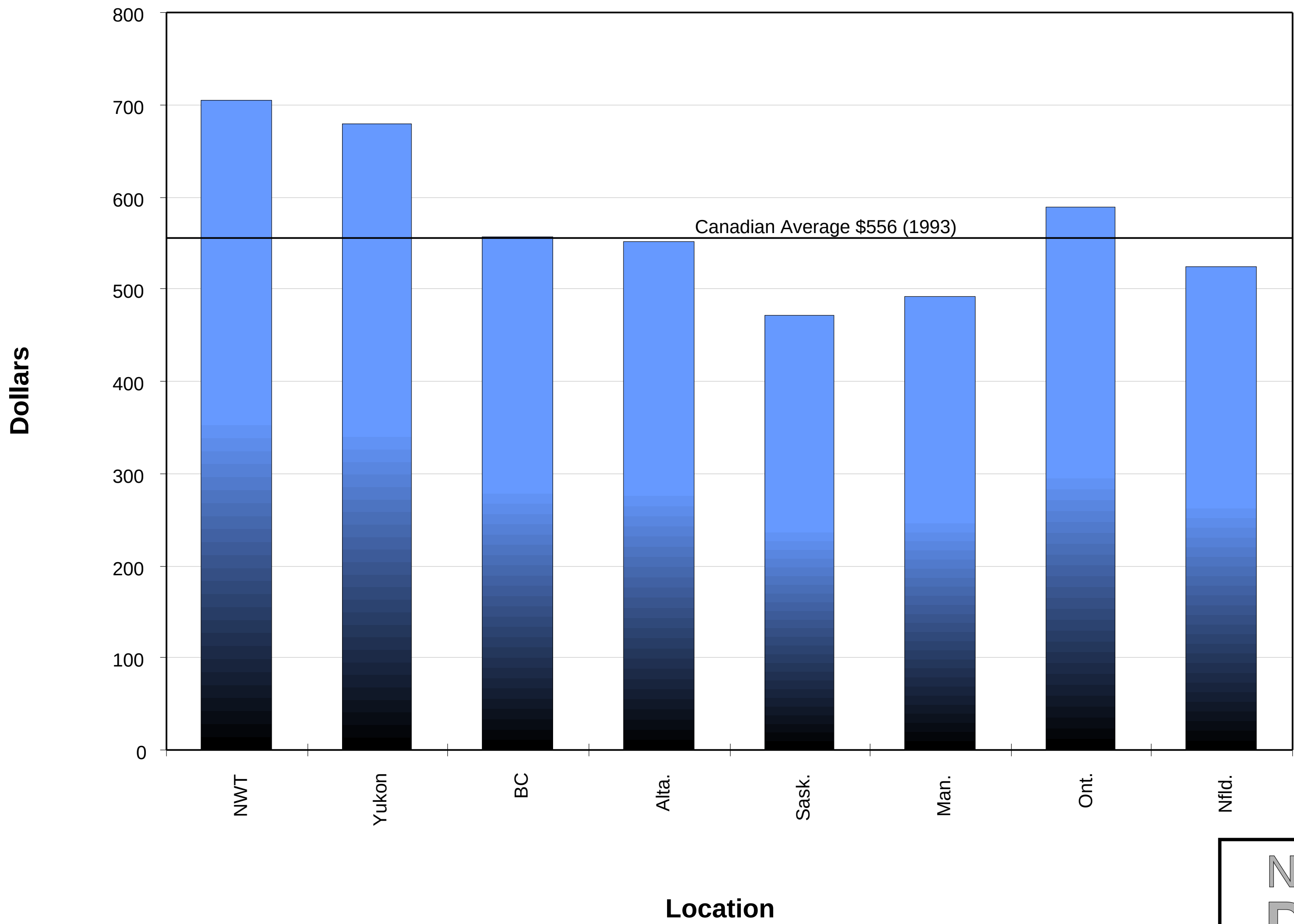

NWT DIAMONDS PROJECT

Figure 4.1-9
Canada Average Weekly Earnings,1993

Source: NWT Bureau of Statistics 1995a

Table 4.1-18
Income Support Programs in the NWT
1992

Program	Dollars Spent
Social housing program	$88,000,000
Unemployment insurance	36,500,000
Social assistance	30,000,000
Training allowances/wage subsidies	20,000,000
Student financial assistance	13,000,000
Harvesters' assistance	2,400,000
Child day care	2,300,000
Total	**$192,200,000**

Source: NWT Education, Culture and Employment 1994.

4.1.9.3 Cost of Living

Residing in the NWT is expensive compared to residing in the rest of Canada. When weekly food costs for a family of four are compared, Coppermine is 97% higher, Hay River is 18% higher, Rae-Edzo is 26% higher and Yellowknife is 25% higher than Edmonton. This is largely due to the small size of the NWT population and distance from supply (Avery, Cooper 1994b).

4.1.10 Infrastructure

The availability of developed land and the infrastructure (roads, water, sewer services) to support an increasing population is a major concern in most northern communities. Increasing the number of lots for home building in a small community is relatively inexpensive compared to the cost of a house and community services. In many instances it only requires surveying the area needed, extending the power line, providing an access road and laying pads of gravel to build on. Water and sewer services are provided by tank truck delivery and pickup. This results in relatively low initial cost of a lot, of $10,000 to $20,000 (depending on how many lots are developed in any one year), and annual operating costs are charged back to the users.

In Yellowknife, however, the provision of water and sewer is extremely expensive. Services in the city are provided by underground piping. The necessity of blasting rock and insulating the system to maintain sub-surface permafrost causes lot development costs to more than double. Typical development costs for lots in 1994 in Yellowknife were $36,000, compared to an average of $15,000 elsewhere in the NWT (Avery, Cooper 1994b). The costs of development in Yellowknife are reflected in prices to users, while in the smaller communities development costs are usually absorbed by the NWT government.

The territorial department of Municipal and Community Affairs looks after community works projects. In fiscal year 1995/1996 the department will undertake 98 community works capital projects, 36 road projects and develop 329 serviced lots in various communities, for a total annual expenditure of $39 million (NWT Financial Management Board Secretariat 1994).

4.1.10.1 Housing/Home Ownership

For over a hundred years, the Dene, having access to trees, built their own housing. This tradition was carried over to the communities, many of which have a long recorded history. As funding became available for new housing in the 1960s, the Dene took advantage of it. During the 1960s and 1970s there was a mini boom in log house construction, which is reflected today in a high rate of home ownership in many small Dene communities.

Inuit, on the other hand, have no access to materials with which to build “modern” houses. Traditionally they had relied on skin tents and snow houses (which were warmer than the wooden structures) in winter. The housing programs offered by the government in the 1960s and 1970s created social housing rather than home ownership, a situation that prevails today in most Inuit communities and in larger Dene communities.

Overcrowding and poor living conditions contribute to a variety of social ills. Inadequate and substandard housing continue to hinder the healthy development of isolated and remote communities in the NWT, in spite of some 25 years of government investment. Demand for housing will increase as the younger generation of Aboriginals reaches adulthood.

Housing of Aboriginal people became a federal government responsibility in the 1950s when Northerners were moved off the land into communities as a result of a public outcry regarding living conditions in the North. The responsibility was transferred to the territorial government in the 1970s. In many communities, where there are no jobs, no one can afford a new house and housing remains a government responsibility.

Housing for Northwest Territories residents is supplied either by the private market or by the territorial government via the NWT Housing Corporation. Generally, private market housing is only available in the larger tax-based municipalities. In the NWT Diamonds Project study region, Yellowknife and Hay River housing is supplied mainly by the private market. In all other study communities new housing is mainly supplied by government.

The programs offered by the NWT Housing Corporation are designed to assist households to acquire and maintain housing that is adequate, suitable and affordable. The programs provide assistance in accordance with a household’s need. Need is defined by lacking access to adequate funding and/or by having a physical disability or social/emotional condition that requires special accommodation.

In 1995, the capital programs of the NWT Housing Corporation fall into two main categories: home ownership programs and financing programs. Families who can afford the operating expenses of a home may receive assistance through one of the corporation's home ownership programs. Assistance is available to acquire a new home or make repairs to an existing family residence.

Under the Owner Build Program, clients are encouraged to participate in the construction of their own homes. Their participation reduces the capital cost of the house as well as the portion of the mortgage the client has to repay. A Lease to Purchase Program allows those families who are unable (or do not wish to contribute labour) to build a house an opportunity to become homeowners.

For clients able to obtain private mortgage financing, the corporation provides the opportunity to purchase a Home Ownership material package. The corporation contracts to purchase and transport the house material package to the client's community and collects the package cost from the client. An interim financing program is also available to these clients to provide bridge financing while the home is under construction. The interim financing program provides financing up to 85% of the principle amount of an approved mortgage to a homeowner/builder who cannot get similar financing from a bank. Many banks are reluctant to provide this form of financing because a client might use the loan money for other purposes and have insufficient funds left to complete the house. The direct lending program helps clients who intend to purchase or build a house on Indian Affairs Branch (IAB) lands to obtain financing directly from the housing corporation. This may be necessary because banks will not make similar financing available due to lack of suitable land tenure.

Older, rental houses may also be purchased by public housing tenants, who can apply up to one-third of their rent toward the sale price.

In 1992, the NWT Housing Corporation conducted a housing needs survey. The survey was conducted with over 14,000 NWT households, and the results indicated 3,584 households in need. This number is up from just over 3,000 units since the last needs survey, conducted in 1990. Thus, the need for housing continues to grow despite the provision of over 1,200 social housing units between 1990 and 1993. Ten percent of the identified need is located in the study communities. This includes 289 households in the First Nations communities and 109 households in Coppermine in core need; that is, households where housing was not suitable, affordable or adequate or a combination of these. Affordability was not considered to be an issue at the time for those who lived in "public or social" housing (NWT Housing Corporation 1992).

The federal government, through the Canada Mortgage and Housing Corporation (CMHC), cost-shared the majority of new housing delivery programs until the end of 1993. As of January 1, 1994, CMHC no longer funds the construction or operating costs of any new social housing units built in the Northwest Territories. However, CMHC funding for the operation and maintenance costs of existing rental housing units will continue (NWT Financial Management Board Secretariat 1994).

The cost of house construction varies from community to community due to the availability of labour, distance from economical sources of supply and weather. In 1993, the NWT Housing Corporation estimated average capital costs for a three to four bedroom house for the communities in the project study area (Table 4.1-19).

Table 4.1-19
Housing Costs
1993

Community	
Coppermine*	$200,000
Hay River*	$120,000
Rae-Edzo	$131,000
Yellowknife	$127,000

* Adjusted - personal communication.
Source: NWT Housing Corporation in Avery, Cooper 1994b; NWT Economic Development and Tourism 1993; pers. comm. Hay River 1995a.

Operating costs are not generally available for private housing, however the average annual cost of $12,705 per unit for NWT social housing gives an indication of the cost of operating a home in the NWT (Avery and Cooper 1994b).

Generally, northern housing constructed prior to 1970 (Table 4.1-20) is not cost effective to maintain due to poor design and lack of insulating materials designed for the northern climate. An estimated 200 units in the Aboriginal communities in the study area should be replaced, according to these criteria.

4.1.11 Social Infrastructure

4.1.11.1 Education

Educational funding for community schools is provided by the GNWT, Department of Education, Culture and Employment. The only community that collects revenue for school support is Yellowknife. The total departmental budget for the 1995/1996 school year is $256 million (NWT Financial Management Board Secretariat 1995).

Table 4.1-20
NWT Housing Occupied Private Dwellings by Period of Construction
1991

	NWT	Study Area Aboriginal Communities*	Coppermine
Before 1946	185	10	–
1946 to 1960	945	35	10
1961 to 1970	3,320	100	55
1971 to 1980	5,495	115	95
1981 to 1985	2,355	115	45
1986 to 1991	3,775	135	65

* Does not include Dettah, N'dilo.
Source: Canada Census 1991b.

The 1995 operating budget for schools is $144 million. Most of that funding ($140 million) is distributed to school boards for the delivery of education. By the year 2010 student enrollment will grow by 50%, based on a student population increase of 3% a year. This growing demand will continue to put considerable pressure on the school system for some time to come.

The NWT school system consists of kindergarten to grade 12 programs. Sixteen thousand students attend NWT schools full time and part time. The system is highly decentralized: ten boards support individual schools to deliver school programs. There are 80 schools in 59 communities with 32 of these communities offering senior secondary programs, compared to only seven communities ten years ago (Table 4.1-21).

The department has been increasing local control and community participation. As a result attendance has increased from 70% in 1981 to over 85% in 1991. Students are also staying in school longer. The participation rate of students in high school has increased from about 40% to 75%, and the grade 12 graduation rate, though beginning to improve, is still under 30%. Approximately 300 students a year graduate from high school, while the number of young people reaching the age of 15 exceeds 1,000. Graduation rates are one-third the national average.

Adult Education and Training

College level programs are delivered at campus locations in many communities throughout the NWT. The division of Arctic College into one western and one

Table 4.1-21
NWT Education - Schools, Teachers, Enrollment
1994/1995

Region	Number of Schools	Top Grade	Teachers	Full Time Enrollment
Baffin	20	12 (4)*	305	3,758
Beaufort/Delta	8	12 (1)	141	1,528
Dehcho	8	12 (1)	70	585
Dogrib	6	12 (1)	57	826
Keewatin	8	12 (4)	164	1,968
Kitikmeot	8	12 (2)	115	1,389
Sahtu	5	11 (1)	54	556
South Slave	8	12 (2)	149	1,740
Yellowknife	9	12 (2)	264	3,503
	80	**Grade 12:17**	**1,319**	**15,854**

Source: NWT Education, Culture and Employment 1995a.
* Numbers in ( ) indicate the number of schools having that top grade.

eastern college will be taking place over the course of 1995/1996. The two public colleges in the Northwest Territories, created from Arctic College in 1995, offer a broad range of skill training, certificate, diploma and university transfer courses, and are the primary adult education and training delivery agents in the North. College enrollments have increased to over 1,500 full time and 8,000 part time students. Much of this growth has been in the Aboriginal student population, now more than half of the full time post-secondary students.

Career Development

The Department of Education, Culture and Employment also operates Regional Career Centres and provides career counselling and support services in various communities, as well as NWT apprenticeship training, construction worker training, on-the-job training and education and training for employment for social assistance clients. The department also provides loans to the estimated 500 NWT residents a year who are attending university in southern Canada.

Culture, Language and Heritage

The department's culture, language and heritage programs, with the support and direction of communities, strive to collect, preserve and present the history and cultures of the NWT. The department provides funding and technical assistance to museums and heritage projects in NWT communities so that they can document their own heritage.

Early Childhood

The department is also responsible for child day care programs. In 1995 kindergarten programs were offered in every community and there were over 1,000 licenced child care spaces. However, there are more than 9,000 pre-school children, of whom 3,600 are infants. An estimated 20% to 30% of children in the NWT live in poverty; early intervention and education have been shown to play a significant role in alleviating the effects of child poverty.

4.1.11.2 Income Support Program

In 1995, the GNWT will transfer responsibility for social assistance to the department of Education, Culture and Employment. Pilot projects are planned to identify and create stronger links between income support and education, training, life skills and employment (NWT Financial Management Board Secretariat 1995).

4.1.11.3 Health Facilities and Other Community Services

The NWT Department of Health and Social Services budget for fiscal year 1995/1996 is $262 million, of which $121 million is recovered from the federal government. The largest portion of the budget ($99.9 million) is allocated to health and hospital boards to provide health services for NWT residents.

Seven regional hospital/health boards and one public administrator deliver health services across the NWT. They operate six hospitals providing 400 acute and long-term care beds. Use of acute care beds is decreasing overall in the Northwest Territories. The Stanton Yellowknife Hospital, with core specialty services, is the principal referral centre in the Northwest Territories. The boards also operate 43 community health centres, eight community health stations and three medical boarding homes in the Northwest Territories.

In addition, the department provides capital funding for the design and construction of facilities required for the care of children, the elderly and the handicapped. It also provides contribution funding to non-government organizations, delivering alcohol and drug programs and operating safe shelters for victims of abuse.

4.1.11.4 Community Programs and Services

A community programs and services division provides direct program delivery, family support and child protection and community health programs. Social services programs are delivered by community social workers resident in many communities.

Family support and child protection programs provide for early intervention and support to families and children, and statutory child protection services.

Community health programs address environmental health, community wellness and independent living. Environmental health programs include study of contaminants as well as nutrition. Community wellness programs focus on family violence, Human Immunodeficiency Virus (HIV)/Acquired Immunodeficiency Syndrome (AIDS), addictions and suicide prevention. Independent living programs provide services for elders and disabled persons. The total budget for these programs in 1995/1996 is $88.6 million (NWT Financial Management Board Secretariat 1995).

4.1.11.5 Care Giving Organizations

Non-government organizations are playing an increasing role in developing and delivering social programs. Many of these organizations occupy old premises or buildings abandoned by other agencies and require capital funding as well as operating funds. The Department of Health and Social Services supports many of these organizations through annual grants and contributions. The variety of services supported by the department gives an indication of the services available in the NWT (Table 4.1-22).

4.1.12 Policing

The Royal Canadian Mounted Police “G” Division carries out most police work in the NWT under contract to the Territorial Government, covering both federal and territorial matters. Some municipalities have by-law officers. The NWT has a limited number of personnel to police an area comprising approximately one-third of Canada.

The RCMP “G” Division, which oversees the police activity in the NWT, is headquartered in Yellowknife, with subdivisions in Yellowknife, Inuvik, Iqaluit and Hay River. There are 39 detachments and two plain clothes units across the NWT, with 229 full time officers – approximately one officer for every 280 persons – in 1995 (RCMP 1995a).

Figures 4.1-10 to 4.1-13 provide comparative estimates of community violence and abuse in 1994 in the NWT Diamonds Project study communities. Comparisons are provided with some similar Alberta communities. Since NWT populations over the age of 15 can be estimated with some degree of accuracy, and those of Alberta communities are based on a ratio of three adults for every child, these statistical representations should be viewed with caution. All of these population estimates should be regarded as approximate.

Columns A and B represent RCMP cases per 100 population for an average of three large and three smaller communities in Alberta, respectively. Columns C, D, E, F and G represent cases per 100 population for NWT study communities.

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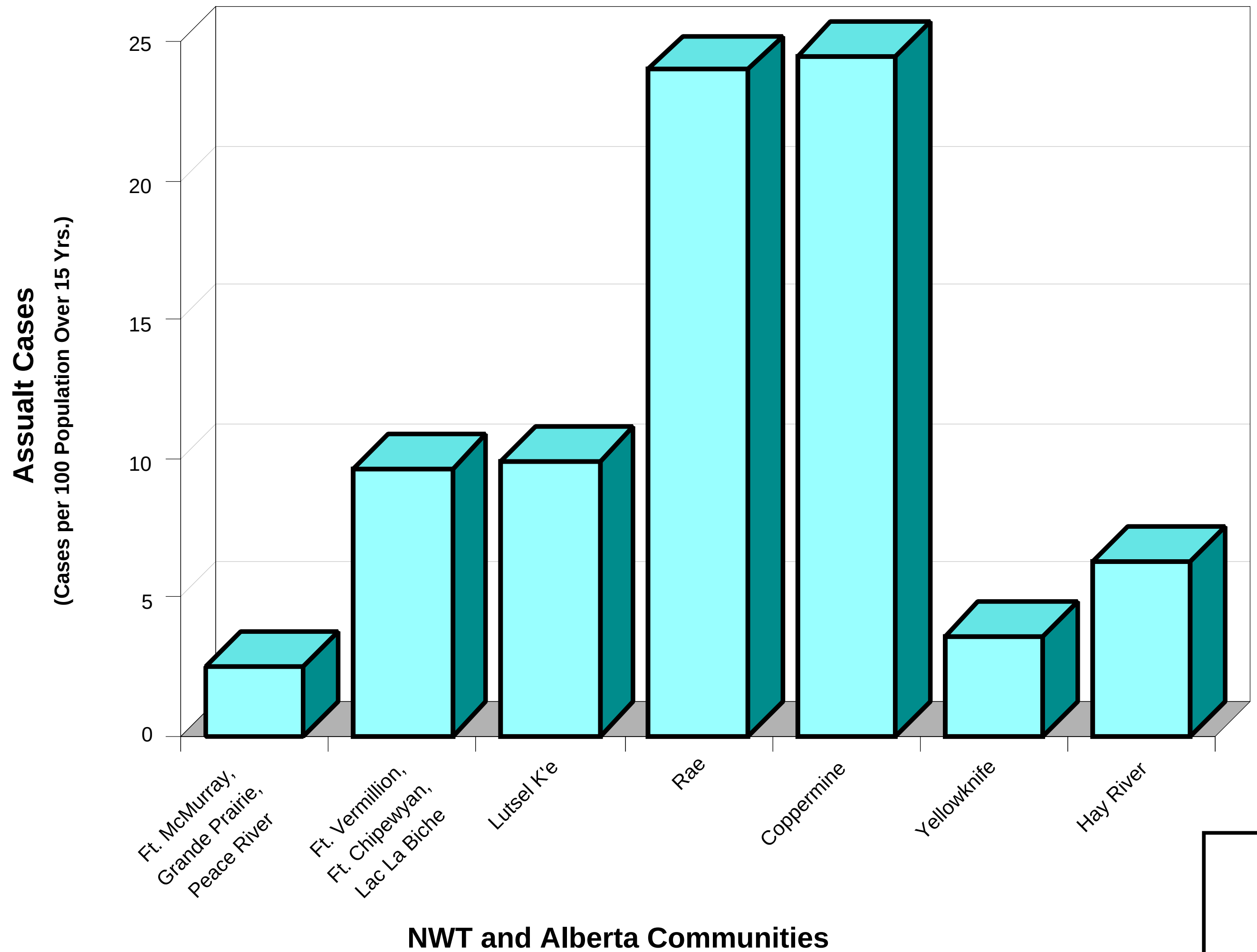

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Figure 4.1-10
RCMP Statistics for 1994—
Total Assault Cases

Source: RCMP Statistics for 1994

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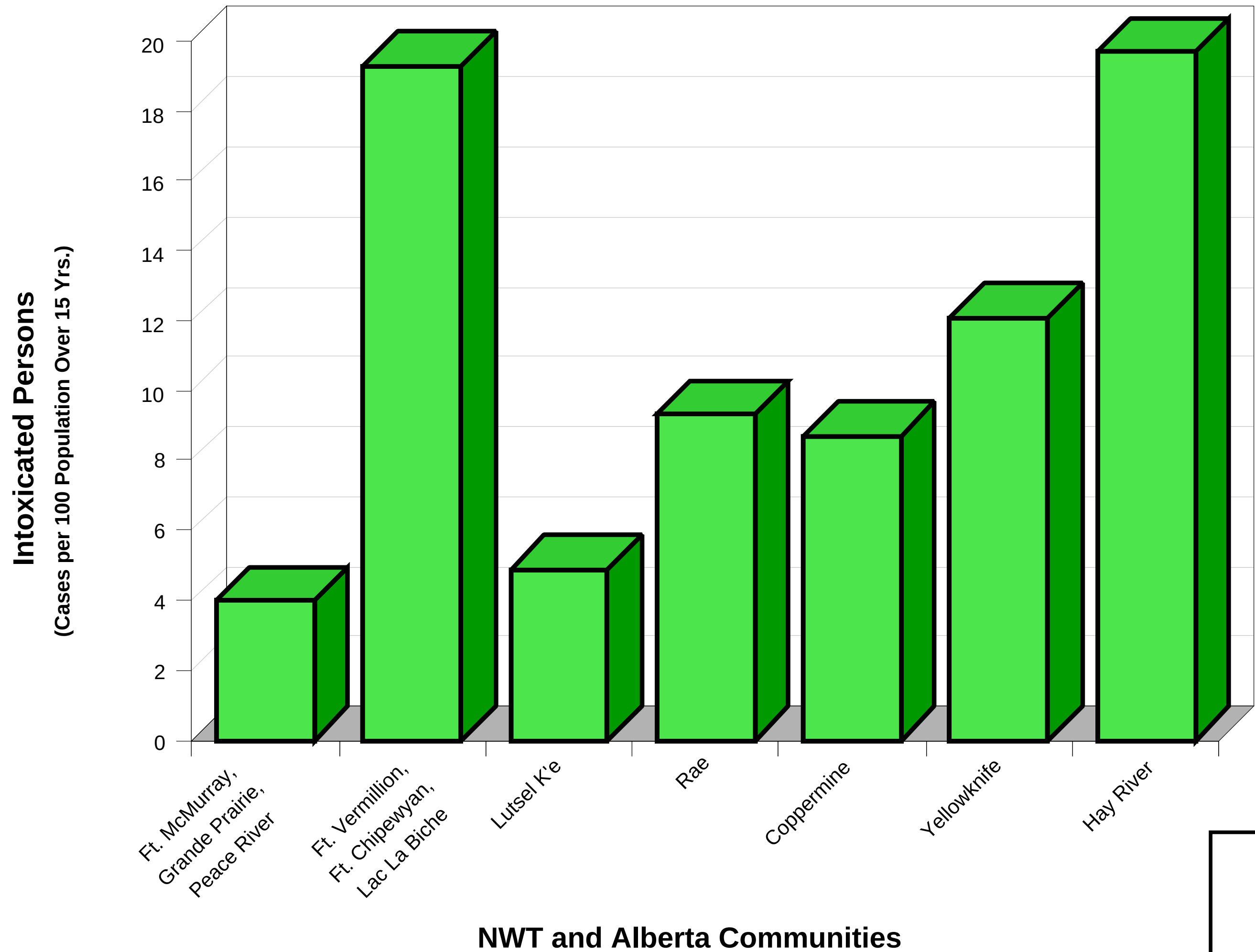

NWT DIAMONDS PROJECT

Figure 4.1-11
RCMP Statistics for 1994—Intoxicated Persons

Source: RCMP Statistics for 1994

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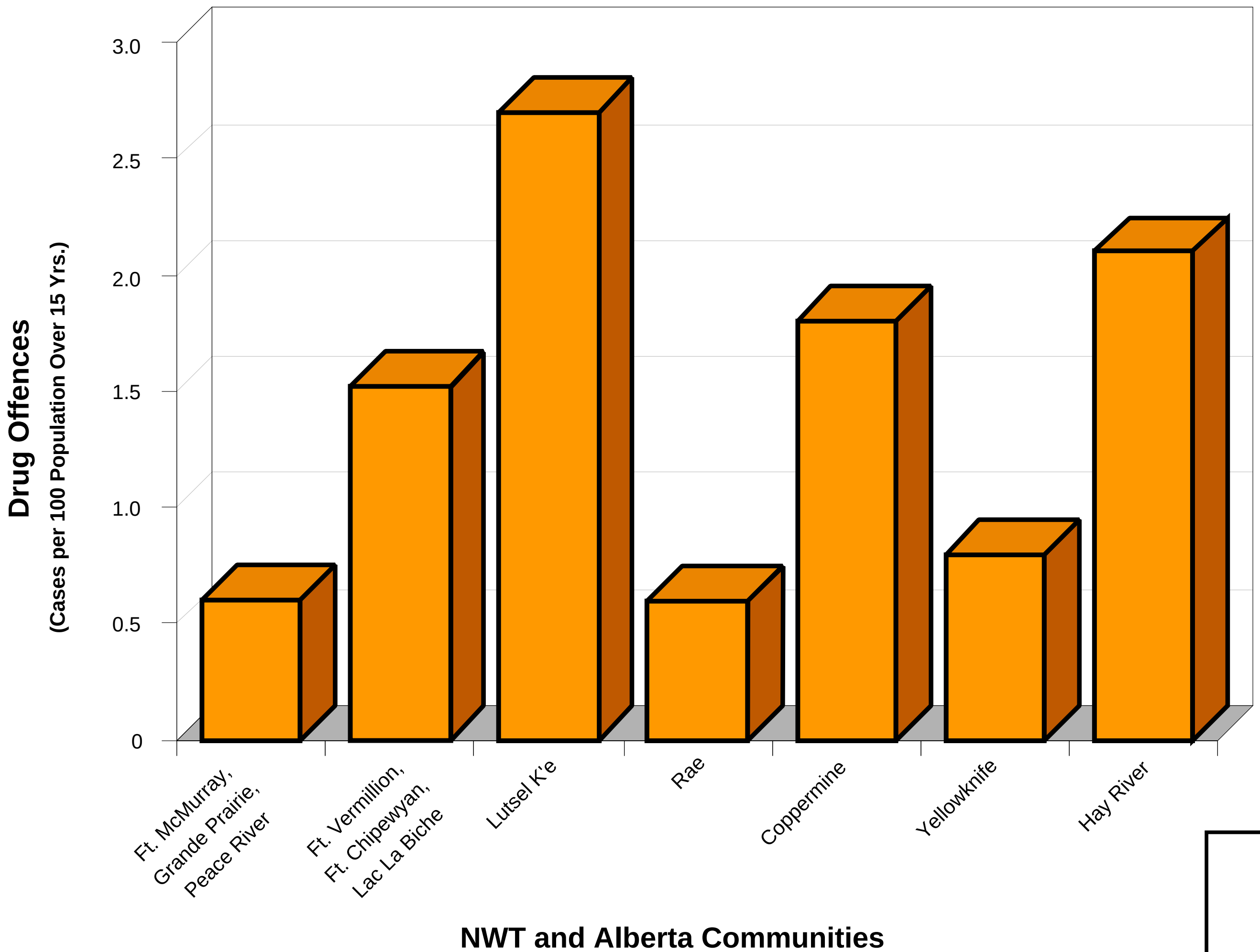

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Figure 4.1-12
RCMP Statistics for 1994—
Total Drug Offences

Source: RCMP Statistics for 1994

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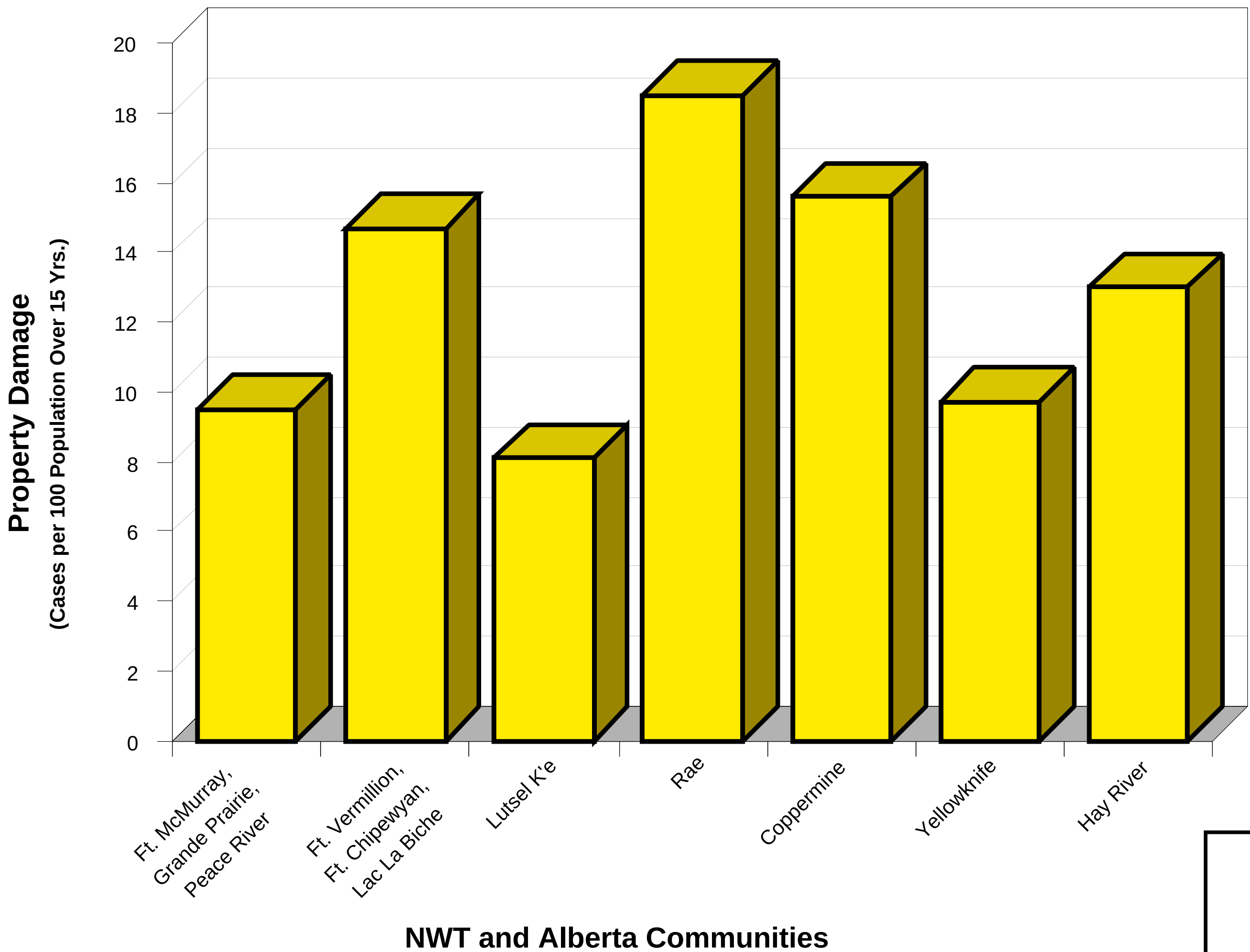

NWT DIAMONDS PROJECT

Figure 4.1-13
RCMP Statistics for 1994—
Property Damage

Source: RCMP Statistics for 1994

Table 4.1-22
Health and Social Services Support for Non-government Agencies
1995 to 1996

Youth Initiatives	
Youth Initiatives	395,000
Youth Initiatives, Alcohol & Drugs	242,000
	$637,000
Family Services	
Foster Parents/Homes	90,000
Family counselling	101,000
Family violence prevention (shelters and support)	2,547,000
Prevention of child sexual abuse	200,000
Suicide prevention	73,000
	$3,011,000
Addictions	
Addiction treatment centres	4,048,000
Community treatment centres	196,000
Community addictions programs	4,533,000
	$8,777,000
Other Services	
Non-profit health organizations	541,000
Community wellness programs	301,000
Centres for elders, physically or mentally challenged	3,265,000
	$4,107,000
Total	**$16,532,000**

Source: NWT Financial Management Board Secretariat 1995.

Northwest Territories Aboriginal communities have a lower rate of alcohol cases than comparable Alberta communities due in part to prohibition. Distance from supply and very high transportation costs may also play a part. The two larger study communities, Yellowknife and Hay River, show a high case load of alcohol related problems. Both communities have a number of bars, a large single population and a large number of visitors from other communities.

Assault stands out as a major problem in two NWT study communities: Rae and Coppermine. Total assault cases include sexual assault. RCMP report the fewest drug cases per 100 population in Rae, and the most in Lutsel K'e.

Property damage cases (break and enter, theft, possession of stolen goods and fraud) appear to be a problem in all NWT study communities.

4.1.13 Commercial/Industrial Infrastructure

Generally only the larger NWT communities have sufficient markets to have developed a commercial/industrial infrastructure. Apart from Yellowknife and Hay River, discussed elsewhere in this volume, other centres with the potential to offer a range of basic services include Inuvik, Norman Wells, Cambridge Bay, Rankin Inlet and Iqaluit. All of these communities have the resources to provide commercial space and attract, or have in the past attracted, a range of service industries.

4.1.14 NWT Revenues and Expenditures

The NWT main estimates predict revenue of $1,212 million in 1995 and expenditures of $1,231 million. An estimated $194 million was to be allocated to capital projects, with the balance of $1,037 to be spent on operations and maintenance of government services. The budget estimate is expected to leave the GNWT with a $38 million deficit by April 1996 (NWT Financial Management Board Secretariat 1995).

The government obtains most of its funding from the Government of Canada (Figure 4.1-14). Approximately 17% of revenues are derived from sales of goods and services, cost recoveries and taxation (11.64%) (NWT Financial Management Board Secretariat 1995).

4.1.14.1 Gross Domestic Product

The most widely used measure of economic growth is the Gross Domestic Product (GDP). Table 4.1-23 shows the expenditure based NWT GDP for 1986 and 1993. These figures represent market prices.

By this measure the NWT economy did extremely well from 1980 to 1990. Economic growth was the fastest in Canada, at times exceeding 20% per year.

In the early and mid-1980s, most investment in the NWT was a direct result of Petroleum Incentive Program (PIP) grants and mineral exploration inspired by flow through share tax breaks. PIP grants precipitated an oil and gas exploration boom in the Beaufort Sea and High Arctic Islands, as well as construction of the pipeline from Norman Wells to Alberta. Mineral exploration led to the opening of the Polaris mine.

With the exception of exports – mainly minerals – virtually all growth over the past four decades was directly or indirectly attributable to government (mostly federal) spending. This took the form of both transfers to individuals and

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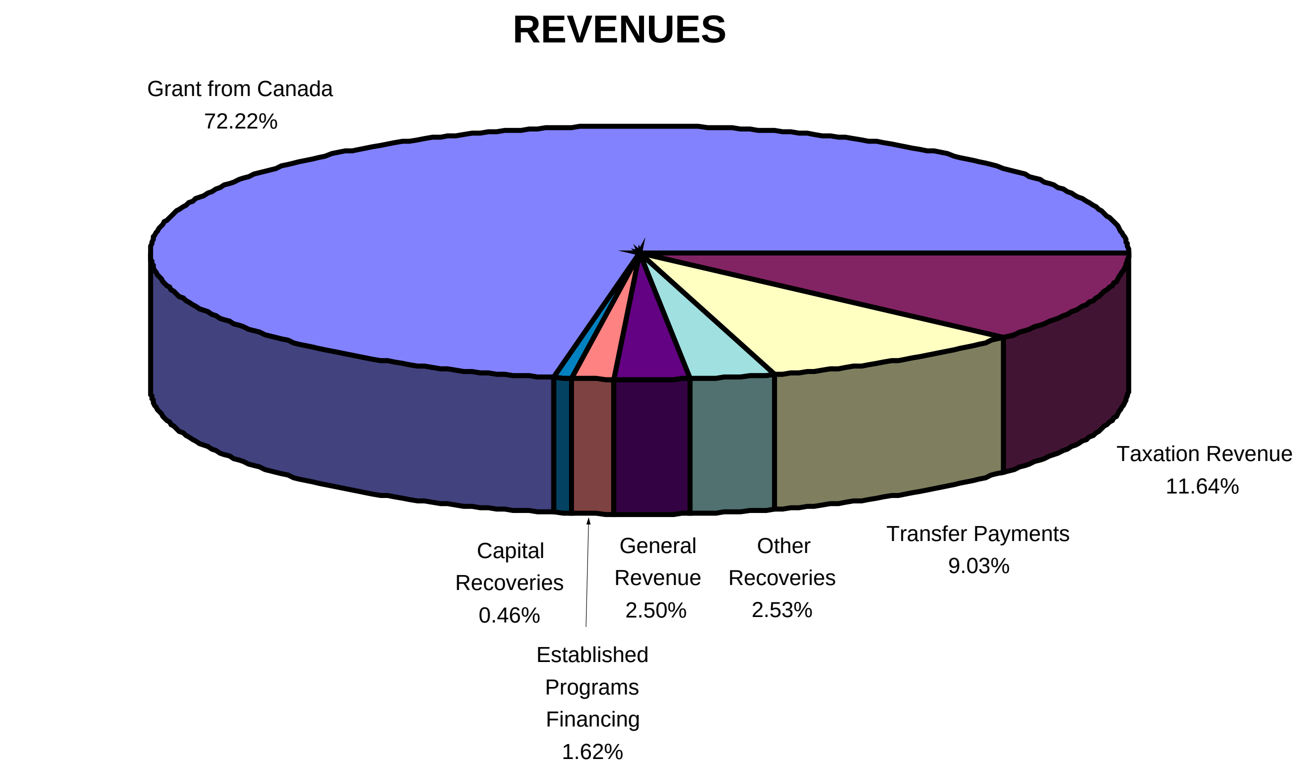

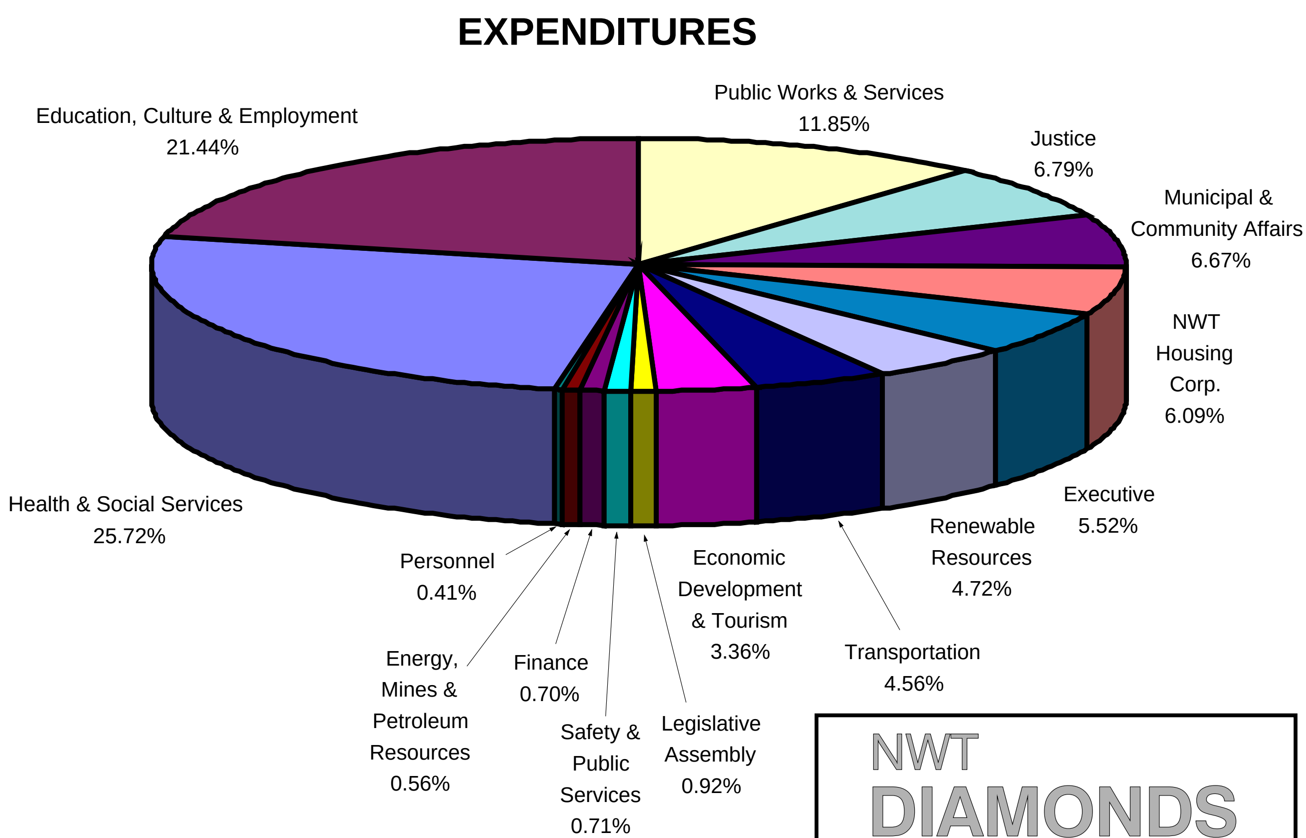

NWT DIAMONDS PROJECT

Figure 4.1-14
NWT Government Revenues and Expenditures, 1995

Source: Financial Management Board Secretariat 1995

Table 4.1-23
Northwest Territories Gross Domestic Product
Expenditure Based

Annual, Millions of Dollars	1993	1986
Personal Expenditures	778	521
Consumer goods/services		
Government Expenditures	1,163	711
Goods and Services		
Capital Investment	428	857
Government	246	168
Business	182	689
Final Domestic Demand	2,369	2,089
Inventories	7	4
Net Exports	<242>	<380>
Gross Domestic Product	**2,134**	**1,713**

Source: NWT Bureau of Statistics 1994b.

investments to develop infrastructure such as housing, educational, recreational and health facilities, transport systems, etc., as well as the rapid expansion of government itself. Transfers to territorial residents soared by 333% in the 1970s and 1980s versus 187% nationally, and the number of public servants more than quadrupled.

In 1990, 1991 and 1992 the GDP for the NWT dropped. This reflected a drop in business investment, primarily in non-residential construction, and marked the end of a decade of major business investment. One reason for the decline in business investment was a marked decline in business profits. At least part of this decline in profits can be attributed to low prices for NWT minerals and oil and gas production (Tables 4.1-13 and 4.1-14). In 1993, although business investment continued to decline, consumer goods and service expenditures and government capital expenditures caused the GDP to rise approximately 1.5% over 1992 levels, the first rise since 1989.

Table 4.1-24 provides a different perspective on the GDP. Here factor cost is used to determine output by industry.

The major determinants of territorial growth according to this measure are (in percentage terms) mining and oil and gas, 20%; government, 22%; construction, 10%; finance, personal and business services, 20%; retail businesses, 5%; and transportation, 4%. Of the NWT's $626 million in exports, mining accounts for around 62% followed by oil at 30%. Combined renewable resource exports, arts and crafts and shipments of natural gas account for the remainder (NWT Bureau of Statistics 1994b).

Table 4.1-24
Northwest Territories Gross Domestic Product by Industry
Millions of 1986 $

Annual, Millions of 1986 Dollars	1993	1986
Business Sector	**1,034.9**	**1,140.8**
Agriculture	1.7	.4
Fishing and Trapping	2.6	4.2
Logging and Forestry	1.0	1.1
Mining, Quarrying, Oil	306.2	458.3
Manufacturing	14.6	11.7
Construction	153.4	177.2
Other Utility	35.2	56.5
Transportation & Storage	67.2	77.1
Communication	64.8	41.6
Wholesale Trade	15.8	10.6
Retail Trade	62.1	45.7
Finance, Insurance, Real Estate	190.7	148.1
Community/Bus. Personal	119.6	108.2
Non-business Sector	**468.9**	**398.6**
Government	328.2	287.2
Community/Personal Services	121.8	93.0
Other Non-business	18.8	18.3
Goods Producing	**514.8**	**709.4**
Service Producing	**988.9**	**830.0**
All Industries	**1,503.7**	**1,539.4**

Source: NWT Bureau of Statistics 1994b.

4.2 First Nations Communities

Part of the project study area is the traditional homeland of the Dene, who have lived in the area for more than 1,000 years. In the past their lifestyle was nomadic, adapting to the seasonal wanderings of the animals that sustained them. Large land animals such as caribou and moose, as well as small game such as rabbits, sustained the Dene in the study area. Fish were important at certain times of the year.

Dene traditional lands do not coincide neatly with political boundaries. There were no permanent borders in the past. Many factors contributed to this seeming looseness of territorial boundaries. The forested area changes, over generations, or sometimes, overnight. Forest fires are a significant agent of environmental shift.

Plant and animal resources also fluctuate from year to year according to their own cycles. The movements of Dene were affected accordingly.

Boundaries also change because of interaction with others. Land was shared for hunting and travelling and, over time, groups intermixed or sometimes disappeared. War and disease affected population distribution, and boundaries shifted to accommodate settlers.

The Dene of the study area are Dogrib, Yellowknives and Chipewyan. Their history was passed down orally in stories from generation to generation and in landmarks familiar to the elders. This information is only now being recorded by other means. Written references are restricted to the comments of a handful of explorers and missionaries or, more recently, anthropologists. No Aboriginal historian has yet recorded the story of the Dene.

Oral history remains the current basis for research on land use, and since elders are still living who can remember the way of life before the area was settled, their recollections are invaluable. There are also landmarks and signs for those who can read them (the elders, and hunters and trappers who still make a living from the land). These signs include arrangements of rocks, pruned trees and subtle disturbances of the ground covering. These indicate camping spots, good hunting places or perhaps a revered burial ground. There are also well travelled routes leading north and east through the forest to the barrenlands, dotted with campsites along the way. Each summer, autumn and winter, many of these routes are still in use. Whole families set out by canoe or by snowmobile and travel long distances to reach a favourite lake or hunting spot.

Two of the more familiar names in Canadian exploration visited the study region; Alexander Mackenzie, in 1793, looking for the big river that drains the Great Slave Lake, and Sir John Franklin, who led an overland expedition to the Arctic coast through the area starting in 1819.

4.2.1 Overview Setting

The study area includes seven Dene communities, four described as Treaty 11 Dogrib and three described as Treaty 8 Dene communities. Combined, their total population is estimated at 3,032 in 1995 (NWT Municipal and Community Affairs 1994a).

Because of their proximity to Yellowknife, all the communities are influenced by activity in the city. Transportation routes are tied to Yellowknife, and supplies for the communities often travel via Yellowknife.

4.2.1.1 Rae-Edzo

The largest Dogrib community, Rae, and its sister community, Edzo, are located on Marion Lake, 113 air km NW of Yellowknife (Figure 4-1).

Traders reached the area in the 1790s as a result of Alexander Mackenzie's trip. For a time, the area supplied food to less fortunate posts south of Great Slave Lake. A number of skirmishes occurred between the Dogrib and the Yellowknives, who were attempting to control trade, until 1823, when Dogrib Chief Edzo made peace with Akaitcho of the Yellowknives.

A Hudson's Bay Company post, called Fort Rae, was established near the shore of Great Slave Lake in 1852 by the arctic explorer Dr. John Rae. By 1890, there were some 600 Dene trading there. A rival company set up a post at the point where travel routes converged, on Marion Lake, and the Bay was forced to move to what is now Rae in 1904.

The Dogrib, under Chief Monfwi, signed what they thought was a peace treaty, Treaty 11, at Rae in 1921. As early as 1930, the Dogrib protested that their understanding of the treaty was different from that of the Government of Canada.

Many Dogrib families continued to alternate between bush and settlement living well into the 1950s. A Roman Catholic mission convalescent hospital was established in the 1940s. By 1959, electricity was brought to Rae, and a year later an access road connecting with the Mackenzie Highway was constructed.

The town site of Edzo, about 24 km from Rae, was developed in 1965 by the NWT government in an attempt to provide better sanitation. A large school and hostel were built at Edzo, and the Rae school was closed in 1971. However, few Rae residents were willing to relocate, and today students are bussed to the school (Outcrop 1990).

Rae businesses attract some highway traffic, and the community has excellent potential for low impact naturalist travel. To date, businesses cater mainly to community needs. Services include gas and vehicle repair, motels, a coffee shop and grocery and department stores. Rae also supports a number of contractors and two building supplies businesses (NWT Economic Development and Tourism 1995a and b).

4.2.1.2 Rae Lakes

Rae Lakes is situated midway between Great Slave and Great Bear lakes, on a point between Rae Lake and Lac Ste. Croix, on the Camsell River system, the traditional route from Rae to Great Bear Lake (Figure 4-1). Although some families lived there prior to the 1970s, the community started to grow larger at that time, and services now include a new hotel, a store, school and airport. A winter road links Rae Lakes with Wha Ti and Rae-Edzo (NWT Economic Development and Tourism 1995c).

4.2.1.3 Wha Ti

A Northwest Company trading post was established here in the heartland of the Dogrib in 1793 to trade for food for posts south of Great Slave Lake. The post closed in 1817 due to disruptions in the fur trade, and the Dogrib travelled to larger posts at Wrigley and later Fort Rae.

Josue Beaulieu and Jeremie Keha from Lac la Martre signed Treaty 11 at Rae in 1921 as councillors to Chief Monfwi (Fumeleau 1975).

Wha Ti is located on the southeast shore of Lac La Martre, a large lake with excellent fishing (Figure 4-1). At the height of the commercial fishing era, there was an attempt to establish a commercial fishery here. A processing plant was constructed and later abandoned.

There were several log houses on the shores of Lac La Martre when a school was built in the settlement in 1955. The community has continued to grow steadily. There is a community store, a hotel, a fishing camp, school and airport. Wha Ti is also linked to Rae Lakes and Rae by winter road (NWT Economic Development and Tourism 1995c).

4.2.1.4 Snare Lake

Snare Lake is located on the Snare River, a traditional Dene route connecting the rugged Precambrian shield area north of Rae and the Yellowknife River system to the Coppermine drainage system and the barrenlands (Figure 4-1). The Dene led Sir John Franklin's 1819 expedition to Winter Lake near Snare Lake, where even in winter there was good hunting. Franklin wintered here twice in the 1820s.

Germain, councillor to Chief Monfwi and leader of the Detchilaotli or Barrenland-Snare Lake Band, signed Treaty 11 at Rae in 1921.

Snare Lake began to grow when a respected elder and former chief, Alexis Arrowmaker, brought several families to the area in the 1960s to preserve traditional lifestyles and values. The community now has a hotel with tourism outfitting, a store, a school and an airport (NWT Economic Development and Tourism 1995c).

The Snare Lake area supplies Yellowknife and Rae with hydro power from a series of dams on the Snare River. The Dogrib recently entered into an agreement to add more capacity to the system by building a dam and selling the power to the NWT Power Corporation (NWT Power Corporation 1995a). Snare Lake is reached by air from Yellowknife. The closest community to the Proponent's proposed mine, Snare Lake is 188 air km away, across a height of land that puts it in a different drainage system.

4.2.1.5 Dettah

Dettah, on the east shore of Yellowknife Bay on Great Slave Lake, is approximately 27 km by highway and 6 km by water or ice road from Yellowknife (Figure 4-1).

By 1782, the Yellowknives were the most powerful group of Dene in the region due to their involvement in the fur trade. A trading post, (Old) Fort Providence, was established near present day Dettah by the Northwest Company just before Mackenzie's visit. The post manager also welcomed Sir John Franklin in 1822 and introduced him to Akaitcho, the Yellowknives Chief who provided guides and life-saving assistance to Franklin (Sturtevant 1981a).

Together with N'dilo, the only other Treaty 8 community on the northeast shore of Great Slave Lake, Dettah provides access to hunting areas north and east of Yellowknife. Dettah was one of a number of seasonal fishing camps on Great Slave Lake before Yellowknife was established across the bay in the 1930s. These camps were devastated by influenza in 1928. The remaining families from a number of camps moved to Dettah in the 1930s. They were joined in the 1950s by Dogrib and Chipewyan Dene who had settled closer to the Yellowknife mines and now wanted to live a more traditional lifestyle (Sturtevant 1981b).

Dettah draws most business services from Yellowknife, but has a small school named after Kaw-Tay-Whee of the Yellowknives, who brokered the peace between Akaitcho and the Dogrib Chief Edzo.

4.2.1.6 N'dilo

Located on a long narrow island in Yellowknife Bay, N'dilo is a small Treaty 8 community that draws all its services from Yellowknife. Like Dettah, the community has a mixture of Dene families, some of whom used the site as a fishing site for generations.

Some residents of both N'dilo and Dettah still hunt, trap or fish for a living, while others work in the city or at the mines. The Yellowknives Band, which represents both communities, is involved in a number of Yellowknife businesses.

4.2.1.7 Lutsel K'e

Located on a peninsula on the south shore of Great Slave Lake, Lutsel K'e is 200 km east and slightly south of Yellowknife (Figure 4-1).

The Caribou and Yellowknives Chipewyan moved into the area in the late 17th century. By the end of the 18th century, smallpox had decimated the Caribou people. The Yellowknives, together with the survivors, for a time controlled trade in the region.

They were represented at the signing of Treaty 8 in Fort Resolution. Their principal concern at the time was the right to hunt, as many families still lived in the area between the present site of Lutsel K'e and Yellowknife (Fumeleau 1975).

The Hudson's Bay Company selected the site in 1925 in an attempt to cut off trade at independent posts in Fort Resolution.

Families from the eastern end of Great Slave Lake, and as far south as Lake Athabasca, shifted their activity to the new post. Homes were built in 1954 and a school was added in 1960.

4.2.2 People/Demographic Profile

The total population in the First Nations study communities is estimated at 3,032 in 1995 (Table 4.2-1). The Dene communities have a high proportion of children under 15, an estimated 34%, and an estimated 6% of total population over age 65 (Table 4.2-2). The only community in the study area with any significant non-Aboriginal population is Rae-Edzo. The 1991 census suggests that there were 120 non-aboriginals in Rae at that time, or 8% of the population (Table 4.2-3).

Table 4.2-1
Population Growth First Nations Communities

	Census 1986	Census 1991	MACA Estimate 1995	Bureau of Statistics 1996
Rae-Edzo	1,378	1,521	1,593	1,615
Rae Lakes	183	252	263	269
Wha Ti	345	392	408	412
Snare Lake	119	127	128	124
Dettah/N'dilo*	131/131	150/160*	150/200**	158/170
Lutsel K'e	273	286	290	290
Total	**2,560**	**2,888**	**3,032**	**3,038**

* Outcrop estimate based on housing in 1992.
** Outcrop estimate based on housing in 1995.
Note: The hamlet of Rae-Edzo estimated its population at 1,824 in 1994 (UMA 1994).
Sources: Census of Canada 1991b; NWT Municipal and Community Affairs 1994a; NWT Bureau of Statistics 1993.

Table 4.2-2
Population by Age and Sex
1991

		Total	0 to 14	15 to 24	25 to 44	45 to 64	65 +
Rae-Edzo	Males	805	275	190	205	85	50
	Females	715	265	155	160	95	35
	Total	**1,510**	**540**	**345**	**365**	**180**	**85**
Rae Lakes	Males	130	45	20	40	5	10
	Females	125	45	30	25	15	10
	Total	**255**	**90**	**50**	**65**	**20**	**20**
Wha Ti	Males	210	90	50	45	20	10
	Females	180	75	30	35	15	10
	Total	**390**	**165**	**80**	**80**	**35**	**20**
Snare Lake	Males	65	20	10	15	n/a	5
	Females	65	25	10	10	10	10
	Total	**130**	**45**	**20**	**25**	**10**	**15**
Dettah/N'dilo	Males	n/a	n/a	n/a	n/a	n/a	n/a
	Females	n/a	n/a	n/a	n/a	n/a	n/a
Lutsel K'e	Males	150	50	30	40	20	10
	Females	135	50	25	35	25	5
	Total	**285**	**100**	**55**	**75**	**45**	**15**
Total		**2,906**					

Note: Numbers may not add across due to rounding by Census Canada.
Source: Canada Census 1991b.

Table 4.2-3
Ethnic Composition 1991
Rae-Edzo, Rae Lakes, Wha Ti, Snare Lake, Dettah/N'dilo, Lutsel K'e

	Total	Rae-Edzo	Rae Lakes	Wha Ti	Snare Lake	Dettah/ N'dilo	Lutsel K'e
Inuit		4	-	-	-	-	-
Dene		1,309	247	375	125	154/170	268
Metis		88	5	5	-	-	-
Non-aboriginal		120	-	12	2	4	18
Total	**2,906**	**1,521**	**252**	**392**	**127**	**328**	**286**

Note: Numbers may not add across due to rounding by Census Canada.
Source: NWT Bureau of Statistics 1995b; Population Estimates 1991.

The population of the Dene communities is estimated to have increased by approximately 20% since the 1986 census, largely as a result of births rather than in-migration.

Almost 60% of the First Nations population over 15 years of age has less than a grade 9 education. Only 15% have a trade certificate, diploma or a degree, according to the 1991 Census (Table 4.2-4) (Canada Census 1991b.)

Table 4.2-4
Education Levels 1991
Rae-Edzo, Rae Lakes, Wha Ti, Snare Lake

	Rae-Edzo		Rae Lakes		Wha Ti		Snare Lake		
	Males	**Females**	**Males**	**Females**	**Males**	**Females**	**Males**	**Females**	**Total**
Population 15 years & over	530	445	85	70	125	105	40	35	1,435
Less than grade 9	290	250	50	45	80	70	30	30	845
Grade 9 - 13 without Sec. Certificate	115	95	-	10	10	15	10	-	255
Grade 9 - 13 with Sec. Certificate	15	10	-	-	-	10	-	-	35
Trades Cert. or Diploma	15	-	-	-	-	-	10	-	25
Some Univ. or Non-Univ. without Diploma	25	20	10	10	15	-	-	-	80
Univ. or Non-University with Diploma	50	45	20	10	25	15	-	-	165
University Degree	15	20	-	-	-	-	-	-	35

Note: Numbers may not add correctly due to rounding by Census Canada. Figures for Dettah and N'dilo are not available.
Source: Census of Canada 1991b.

Individuals with less than a grade 12 education are at a disadvantage in competing for jobs in the highly skilled, highly educated labour force that prevails in Yellowknife (Lutra 1995). The number of students graduating from grade 12 remained stable for the past seven years and has only just started to increase. Each year, from 1987/1988 to 1993/1994, an average of 115 students from Yellowknife and other communities graduated from grade 12 in Yellowknife, which until recently had the only grade 12 courses. The NWT government anticipates that the number of students enrolled in Rae-Edzo will continue to increase as the population increases and as higher grades are introduced in community schools and delivery methods change. The impact of the grade 12 program in Rae-Edzo is not reflected in these statistics. The overall NWT graduation rate is expected to rise from approximately 28% of grade 12 enrollment in 1995 to 38% of grade 12 enrollment in the year 2001 (Lutra 1995).

Approximately 70% of the total NWT population over the age of 15 in 1994 were in the labour force. Labour force participation in the First Nations study communities ranges widely, from 62% in Lutsel K'e to less than 35% in Snare Lake (Table 4.2-5). Overall participation in the labour force is estimated at 48% in 1994. This rather low rate increases somewhat when an alternative definition is applied to the numbers, which are based on unemployment statistics. To provide a truer picture of the northern labour force, the NWT Bureau of Statistics accumulates data on persons who had not looked for work because they perceived no jobs to be available (GNWT Statistics 1994). This increases the participation rate to 67% in Wha Ti, 55% in Rae-Edzo and 41% in Snare Lake (NWT Bureau of Statistics 1994a).

Table 4.2-5
First Nations Communities Labour Force
1994

Community	Population Over 15 Yrs	Labour Force 1994	Participation Rate	Employed 1994	Unempl. 1994	Unempl. Rate
Dettah	148	71	48%	50	21	30%
Wha Ti	261	158	61%	79	79	50%
Rae-Edzo	1,101	573	52%	334	239	42%
Rae Lakes	174	65	37%	58	7	11%
Snare Lake	92	29	32%	24	5	17%
Lutsel K'e	223	139	62%	95	44	32%
Total	**1,989**	**1,035**		**640**	**395**	

Source: NWT Bureau of Statistics 1994a.

Unemployment rates vary widely from community to community, and sometimes from year to year, according to the major projects undertaken by government in each community. Therefore, unemployment figures should be viewed with caution and in the light of anticipated government or private spending in the communities. Rae Lakes, in 1994, appeared to have the lowest unemployment rate by Statistics Canada measures (Table 4.2-6). Dettah had an unemployment rate of 30%, Rae-Edzo stood at 42% and Wha Ti, with the highest participation in the labour force, had the highest unemployment rate, at 50%. Adding those who wish to work (but realize there are no jobs) results in unemployment rates ranging from 32% in Dettah to 55% in Wha Ti, with Rae-Edzo, the largest community, having an unemployment rate of 45% (NWT Bureau of Statistics 1994a).

Unemployment as defined by Statistics Canada is also increasing in almost every Dene community in the study region (Table 4.2-6). This has been attributed to two causes, the natural growth of the population of labour force age without a corresponding increase in jobs, and higher participation rates as a result of more young people entering the labour force rather than selecting the traditional economy. As noted in the section on the NWT economy, it has been found that people will allocate their time between traditional activities and wage employment according to the amount of wage employment available.

Table 4.2-6
First Nations Communities Unemployment Growth
1981 to 1994

	Number of Unemployed				Unemployment Rates			
	1994	**1991**	**1986**	**1981**	**1994**	**1991**	**1986**	**1981**
Dettah	21	15	20	5	30%	27%	50%	33%
Wha Ti	80	55	30	15	50%	38%	33%	43%
Rae-Edzo	239	190	110	35	42%	35%	28%	13%
Rae Lakes	6	20	10	15	11%	24%	22%	40%
Snare Lake	5	10	10	0	17%	22%	33%	0%
Lutsel K'e	43	30	15	0	32%	46%	20%	0%
Total	**394**	**320**	**195**	**70**				

Source: NWT Economic Development and Tourism 1994.

Employment statistics do not necessarily indicate full time jobs. In the Dene communities for example, there were 255 full time jobs in 1991 and 569 part time jobs, a ratio of 2.2 part time jobs for every full time job (Canada Census 1991b). Comparable figures for Yellowknife are 6,255 full time and 3,740 part time workers, or 0.6 part time jobs for every full time job. Coppermine had 135 full time workers and 275 part time in the same period, or two part time jobs for every full time job.

4.2.2.1 Employment

Employment figures by occupation reveal the basic economic difficulties in the First Nations communities, with no goods-producing workers and a high proportion of skilled to unskilled workers. The jobs available would be taken largely by skilled workers. Only 30% of jobs in Treaty 11 communities are suitable for unskilled workers. These jobs are built into the various categories shown in Table 4.2-7.

4.2.3 Economic Activity/Sectors

Figures in this section were drawn from the 1991 census, with updated material supplied by the Department of Economic Development. The census figures may be questionable due to the timing of the census and the reluctance of Dene to participate. However, in terms of a portrait of the labour force, the proportion of workers in each sector is probably close to accurate. Readers should note that both N'dilo and, to some extent, Dettah employment is included in the statistics for Yellowknife. Any data on these two communities included here is duplicated intentionally to assist in providing a profile of the Dene communities.

Table 4.2-7
1994 Employment by National Occupation Classification
Treaty 11 Communities

	Number	Percentage
Management, Skilled Office, Clerical	113	21
Sciences, Health, Education, Government	109	20
Arts, Culture, Recreation, Sport	24	4
Sales and Service	199	37
Trades, Skilled, Semi-skilled	100	18
Processing, Manufacturing		
Total	**545**	**100**

Source: NWT Bureau of Statistics 1995d.

4.2.3.1 Government

Government administration and services are the largest employers in the Dene communities. According to the 1991 census, some 470 persons were employed directly by various levels of government in the Dene communities or in education and health services (Table 4.2-8) (Canada Census 1991b). This appears to be too high for the number actually employed in 1994. In Rae-Edzo, which has the largest government sector of the six communities, there are an estimated 150 full and part time positions in government, education and health. An estimated 120 more government positions are distributed among the remaining Dogrib communities and would include hamlet and band management.

4.2.3.2 Retail/Accommodation

The retail and accommodation sector in the Dene communities consists of a small hotel and a store each in Rae Lakes, Wha Ti and Snare Lake. In Rae-Edzo, five businesses provide tourism services, including a motel, restaurants and a seasonal camp. Eight businesses provide a variety of retail services including building supplies (NWT Economic Development and Tourism 1995b and c). Dettah and N'dilo are served by Yellowknife. Lutsel K'e has a hotel and store. A total of some 130 workers had experience in this sector, according to the 1991 census conducted before the hotels and stores in Rae Lakes and Snare Lake were completed.

4.2.3.3 Transportation/Communications/Construction

According to the 1991 census, there were 90 workers in the construction, transportation and communications fields in the Dene communities in 1991.

Table 4.2-8
First Nations Labour Force by Occupation
1991

	Rae-Edzo	Rae Lakes	Wha Ti	Snare Lakes	Lutsel K'e	Total	Percentage
Public Administration/ Education & Health*	235	50	85	20	80	470	58%
Retail/Accommodation/ Food Services/Tourism	75	10	30	-	25	130	16%
Transportation/Commun./ Construction	60	20	10	-		90	11%
Mining/Manufacturing	35	-	10	-		45	5%
Finance/Other Business and Personal Services	25	-	-	-		25	3%
Renewable Resources	25	10	10	10		55	7%
Total	**455**	**80**	**145**	**30**	**105**	**815**	

Note: Includes full and part time employment. Figures may not add due to rounding by Census Canada.
* These numbers are higher than the estimates given in text and may include people who held short duration jobs or participated in short duration public programs.
Source: Canada Census 1991b.

Again, this may be low due to the fact that considerable construction has and is taking place in these communities and more workers will have joined the work force since 1991. Government contracts are normally broken into segments that can be handled in part by community businesses and workers, to help provide employment and training. Each community has a band owned construction company.

An estimated 13 businesses in Rae-Edzo provide services in this sector, including general contractors, highway maintenance, community services and heavy equipment services.

4.2.3.4 Mining/Goods Production

Some 45 residents in the Dogrib communities had jobs in mining, according to the 1991 census. In 1995, an estimated 70 Dogrib and Yellowknives had full time jobs at five of the NWT's operating mines (Colomac, Lupin, Giant, Polaris, Con) (Mine personnel officers pers. comm. 1995).

In 1994, an estimated additional 40 Dene from the Dogrib and Yellowknives communities had jobs connected with the NWT Diamonds Project exploration.

4.2.3.5 Business/Finance

The business and personal services and financial sectors in the Dene communities are very small. Only Rae shows activity in this sector, with both management companies and business services represented. Financial and legal services are available from Yellowknife. Most personal financial activities are handled through the Northern Store or other local businesses; however, the Royal Bank established limited personal banking services on a part time basis in Rae in 1994 (Kuntz 1995). Actual employment in this sector was estimated at 25 in 1991.

4.2.3.6 Renewable Resources

According to the 1991 census, 55 residents had jobs in agriculture, fishing or logging. This estimate does not include the 200 to 300 full and part time workers employed as forest fire crews each summer (Nishi-Khon Forestry 1995). It also does not appear to include any residents of Dettah and N'dilo who work in the Great Slave Lake fishery, and others employed on a part time basis in harvesting firewood for Dene communities and Yellowknife.

4.2.3.7 Traditional Economy

Many residents of the First Nations communities still hunt, fish and trap. Again, the statistics are not very reliable for a number of reasons. However, some material is available, and it leads to the conclusion that more fishing and hunting is actually taking place than is recorded.

Caribou is hunted by three groups: individual General Hunting Licence holders (GHL), the Hunters and Trappers Association (HTA) and non-residents. All these groups supply food to residents of the Aboriginal communities. GHL (these are mainly Aboriginal residents, but some non-aboriginal residents born in the north also hold GHLs) have an annual quota of caribou for home consumption. In addition, the HTA share a commercial meat quota and an outfitter quota. Hunting by non-residents who book hunts with non-aboriginal outfitters also provides meat to native families (Table 4.2-9) (NWT Renewable Resources 1994 a, b and c; NWT Renewable Resources 1989).

Table 4.2-9
Barren Ground Caribou Hunting
Slave Geological Province (Bathurst Herd)

Community	Maximum GHL Harvest Since 1980	Commercial Meat Quota	Commercial Outfitter Quota (Class B HTA)
Coppermine	225	214	100
Yellowknife/Dettah	1,400	*	32
Rae Lakes	2,300	*	50
Rae-Edzo	6,000	*	**
Wha Ti	900	*	**
Snare Lake	1,300	*	**

* These communities share a meat quota of 792.
** These communities share a outfitter quota of 50.
Note: Residents of Lutsel K'e would tend to hunt the Beverly herd, which winters south of Great Slave Lake and ranges east to the Thelon Game Sanctuary.

Source: NWT Renewable Resources 1994a and b; NWT Renewable Resources 1989.

Two caribou herds generally range in the study area, the Bathurst and the Beverly herd. In addition, some woodland caribou can be found south of Great Bear Lake. A caribou yields approximately 54.5 kg (120 lbs.) of meat. A conservative estimate of the caribou harvest for the seven Dene communities would average approximately three caribou per household per year, with those families supplementing the meat part of their diet with store bought meat. In fact, many families would take more caribou than this, perhaps up to six animals per year.

In addition, the Dene hunt moose and snare rabbits for food. Lutsel K'e residents also hunt muskox. Families that have the resources to live off the land also harvest fish for family consumption. Usually these are taken in summer when they can be dried and sometimes smoked to preserve them for winter. This food harvesting activity is a full time job for members of an extended family and helps to explain the relatively low labour force participation rate in some communities.

The NWT Community Harvester Assistance Program provides seed money for equipment required by hunters and trappers associations, such as fuel, snowmachines, boats and temporary and permanent shelter. Statistics from these HTA applications and approved grants provide some insight into the number of GHL holders in each community and the level of activity (Table 4.2-10). In Table 4.2-11, the decline in the number of trappers selling fur reflects both a declining interest in a very difficult lifestyle, as well as the impact of low fur prices.

Table 4.2-10
First Nations Communities Renewable Resources
Summary of GHL Contributions Agreements,
1994 and 1995

Community	1993 GHL Holders	1994 GHL Holders	Grant per Community 1994/1995
Rae	653	663	$65,000
Wha Ti	117	118	$35,000
Rae Lakes	112	112	$33,000
Snare Lake	49	52	$19,000
Yellowknives	223	223	$23,000
Total	**1,154**	**1,168**	**$175,000**

Source: NWT Renewable Resources 1995.

Table 4.2-11
First Nations Communities
Reported Number of GHL Holders Selling Fur
1993 to 1994

	1993	1994	Total Dollar Return Estimate (1994 $)
Rae	133	97	24,736
Wha Ti	37	11	2,314
Rae Lakes	42	15	7,973
Snare Lake	17	2	911
Yellowknives	40	34	2,112
Total	**269**	**159**	

Source: NWT Renewable Resources 1995.

The traditional economy also provides materials and maintains skills useful in the production of arts and crafts. A 1993 estimate suggests there are over 400 people in the Aboriginal communities producing crafts (NWT Renewable Resources

1995). In addition, a tannery has been established in Wha Ti to enable craft producers to tan caribou and moosehide for clothing production.

4.2.4 Income

Personal income in the Dene communities comes from a variety of sources. These include employment, arts and crafts production, unemployment insurance, social assistance and returns from renewable resource harvesting. Table 4.2-12 provides an estimate of the total personal income from various sources for the Dogrib communities and Lutsel K'e. Dettah/N'dilo have not been included here because there is not sufficient background material. These communities are included in Yellowknife.

Business income in the Dogrib communities accrues to the Dogrib people. More than 90% of the Dogrib businesses are owned by Aboriginal entrepreneurs or the band development corporations (NWT Economic Development and Tourism 1995b and c). Some $676,950 in annual band and community economic development funding in 1995 is assumed to be invested in developing Dogrib businesses (Canada, IAND 1995) (Section 4.2.5.10 provides further information on businesses).

Social assistance payments increased over 30% in the period 1991 to 1994 (Table 4.2-13). Some 64% of social assistance payments in fiscal year 1993/1994 were to 18 to 44 year olds (Table 4.2-14). Social assistance payments as an income subsidy, or due to lack of work, amount to 49% of the payments made in 1993/1994 (Table 4.2-15) (NWT Health and Social Services 1995). Lutra (1995) suggests that a lack of basic education may limit the ability of recipients to participate in the labour force.

4.2.4.1 Cost of Living

The cost of living in the Dogrib communities is 45% to 55% higher than in Edmonton, or some 15% to 20% higher than in Yellowknife, according to estimates prepared by Statistics Canada (NWT Bureau of Statistics 1995c). This is due in part to the small number of consumers in each community and in part to the difficulty in delivering goods to many of these communities. Rae Lakes and Wha Ti are estimated to be 55% higher than Edmonton and Rae-Edzo to be 45% higher than Edmonton. Cost of living estimates for Dettah and N'dilo are not available. Lutsel K'e costs are estimated to be 56% higher than Yellowknife.

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Table 4.2-12
Aboriginal Communities
1991 Wage Based Income

	1991								
Community	**Full Time Employment**	**Full Time Average Wage**	**Part Time Employment**	**Part Time Average Wage**	**Total Estimate Wages**	**Total Reported Income**	**Social Assistance FY 1993/ 1994**	**UI Estimate 1994**	**Fur Sales 1994**
Rae-Edzo	170	33,940	325	$11,352	$9,459,200	$11,825,000	$1,275,499	$1,090,301	$24,736
Wha Ti	25	30,000	105	$8,175	$1,608,375	$2,338,000	$631,178	$98,447	$2,314
Rae Lakes	25	25,000	70	$6,720	$1,095,400	$1,426,000	$308,118	$22,482	$7,973
Snare Lake	10	20,000	4	$6,700	$226,800	$449,000	$200,075	$22,125	$911
Lutsel K'e	25	25,000	65	$8,456	$1,174,640	$1,876,000	$271,570	$429,790	$10,685
Total	**255**		**569**		**$13,546,415**	**$17,914,000**	**$2,686,440**	**$1,663,145**	**$46,619**
Average Wage		$27,232		$8,236					

Source: Estimates based on Community Personal Income 1991; NWT Bureau of Statistics 1994c with some adjustments; NWT Bureau of Statistics 1994a; NWT Health and Social Services 1995; NWT Renewable Resources 1995. Figures for Dettah/N'dilo not available.

Table 4.2-13
First Nations Communities
Social Assistance Total Payments by
Fiscal Year Since 1991

1990/1991	$1,900,275
1991/1992*	$1,546,292
1992/1993	$2,230,343
1993/1994	$2,722,273

Source: NWT Health and Social Services 1995.
* Does not include Lutsel K'e.

Table 4.2-14
First Nations Communities Social Assistance by Age Group
Fiscal Year 1993/1994

	Rae ($)	Rae Lakes ($)	Snare Lake ($)	Wha Ti ($)	Dettah ($)	Total ($)
0 to 17	15,217	1,293	–	4,014	–	20,524
18 to 24	304,246	68,945	$35,802	139,443	3,033	551,469
25 to 34	369,155	65,381	58,312	128,865	8,434	630,147
35 to 44	185,757	46,997	73,102	70,841	480	377,177
45 to 49	295,903	102,915	25,806	172,719	11,485	608,828
60 to 64	95,701	13,998	–	111,363	11,015	232,077
65+	8,051	8,474	6,991	3,723	1,403	28,642
Total	**1,274,030**	**308,003**	**200,013**	**630,968**	**35,850**	**2,448,864**

Source: NWT Health and Social Services 1995.

Table 4.2-15
First Nations Communities Social Assistance by Reason
Fiscal Year 1993/1994

	Rae ($)	Rae Lakes ($)	Snare Lake ($)	Wha Ti ($)	Dettah ($)	Total ($)
Income Subsidy	93,109	28,777	20,427	4,679		146,992
No Jobs	543,015	104,204	112,805	47,584		807,608
Not Working	45,210	11,847	4,627	170,839	12,437	244,960
Total	**681,334**	**144,828**	**137,859**	**223,102**	**12,437**	**1,199,560**

Source: NWT Health and Social Services 1995.

4.2.5 Infrastructure – Municipal Government

Of the seven Dene communities, Rae-Edzo and Wha Ti are incorporated as hamlets (NWT Municipal and Community Affairs 1995c). In all communities, community services are supported largely by territorial and federal funding. Municipal band income for the seven Dene communities totaled $3.48 million in 1994. Of that total, 58% comes from the GNWT, 32% from the federal government and 10% from the residents of Rae-Edzo and Wha Ti. In addition, the communities (including Dettah and N'dilo) received $1.13 million in federal band funding and Community Economic Development funding in 1994 (Figure 4.2-1).

Infrastructure, including water supply, sewage services, solid waste services, roads, schools and recreation facilities, are supplied by NWT Government capital funding. Rae-Edzo, Wha Ti and Rae Lakes provide their own municipal services through the hamlet or hamlet contract. N'dilo is supplied with water and sewer services by the City of Yellowknife.

4.2.5.1 Transportation

Rae-Edzo is connected to the Mackenzie Highway by a 19 km access road. All communities have graded roads and most provide some form of regular maintenance. Rae-Edzo has no airport. Average daily traffic between Rae and Edzo is 370 vehicles a day. Between Rae and Yellowknife, local traffic is estimated at 180 vehicles a day. New airports with 914 m long runways designed to handle Twin Otter aircraft were constructed at Rae Lakes, Wha Ti and Snare Lake between 1990 and 1994. Lutsel K'e has an airstrip and shelter as well. Rae Lakes and Wha Ti are linked to Rae-Edzo by a winter road constructed by NWT Department of Transportation and open from mid-January through March. Traffic on the winter road averages 10 to 20 vehicles per day. There are no commercial marine dock facilities at any of the communities. Dettah and N'dilo are connected to Yellowknife by road. The Dettah road, stretching 11 km from Highway 4, is an all-weather road. Traffic averages 200 to 250 vehicles per day, except during the winter months when a 6 km ice road is open between Dettah and Yellowknife. The Department of Transportation estimates 33% of total highway traffic is commercial (NWT Transportation 1993, 1995).

4.2.5.2 Municipal Services

Water is trucked to homes in the First Nations communities. Rae-Edzo also has some buried water lines. Trucked sewage is delivered to lagoons in Rae-Edzo, Snare Lake and Lutsel K'e. All communities have a modified landfill or dump for solid waste. Power is supplied to Rae-Edzo, Dettah and N'dilo from the Snare/Yellowknife hydro system with diesel backup. Rae Lakes, Wha Ti, Snare

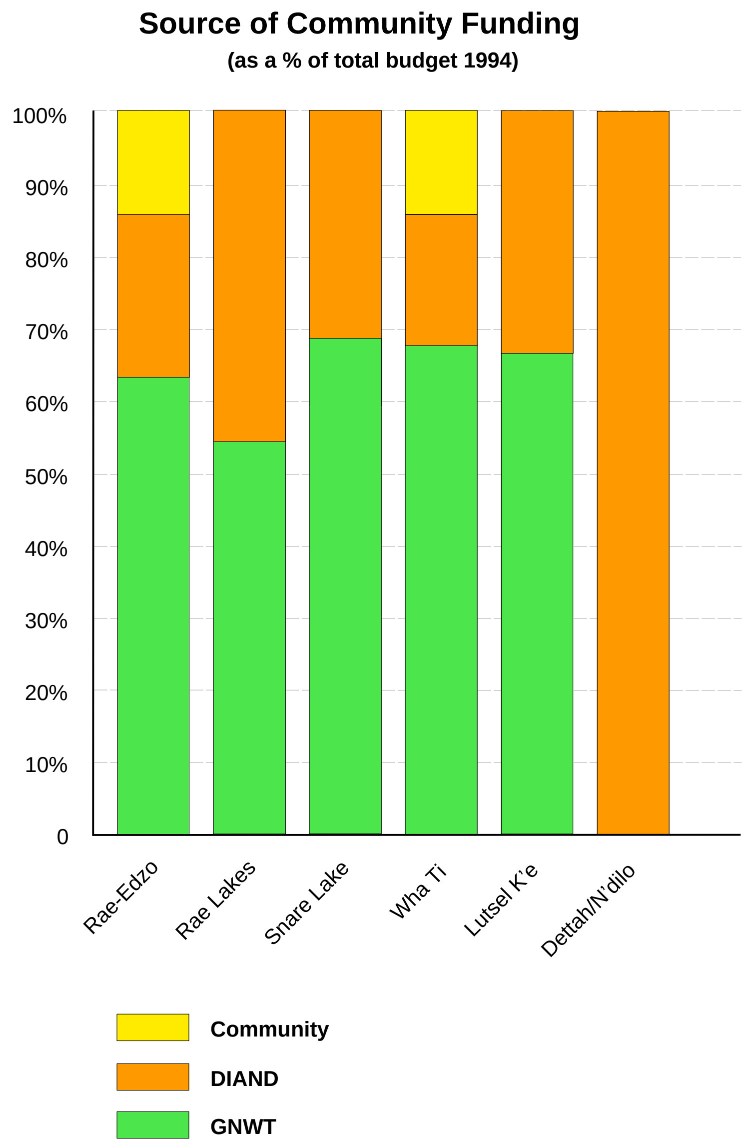

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Figure 4.2-1
Source of Community Funding

Source: NWT Municipal and Community Affairs 1995a; NWT Municipal and Community Affairs 1995b; Canada IAND 1995

Lake and Lutsel K'e are supplied by diesel generator installed by the NWT Power Corporation. Table 4.2-16 provides a listing of community services.

4.2.5.3 Communications

In total, NorthwesTel has some 600 telephone accounts in the Dogrib communities. The Yellowknives communities are included under Yellowknife. All receive CBC and Television North (TVNC) television, as well as CBC and Aboriginal communications FM radio. Rae Lakes and Wha Ti also run community radio stations.

4.2.5.4 Housing/Home Ownership

Housing in the Dene communities is largely single family and, with the exception of Rae-Edzo and Lutsel K'e, the desire for and level of home ownership is very high (Tables 4.2-17 and 4.2-18) (Canada Census 1991b). Approximately 20% of the units in Rae-Edzo were apartment or row housing in 1991. A housing needs survey conducted by the NWT Housing Corporation in 1992 found that 48% of households in the Aboriginal communities were "in Core Need" of housing, that is, houses needed major repairs, or additional housing was required (Table 4.2-18). Core need was determined by suitability, affordability, adequacy or a combination of any of these factors (Tables 4.2-19).

4.2.5.5 Recreation

Community recreation infrastructure in the Dene communities includes school gyms in four communities and community halls in six communities. Rae-Edzo has an arena, a curling rink and a (seasonal) pool. Play area development is in the NWT capital plan for most communities in 1997 and 1998 (NWT Municipal and Community Affairs 1994a and 1995d). Most communities also have access to video rentals.

4.2.5.6 Education Facilities

The Dogrib Divisional Board of Education was established in 1989 and governs schools in Dettah, Wha Ti, Rae-Edzo, Rae Lakes and Snare Lake. Student enrollment in 1995 was 826, with 51 teachers and support staff. Lutsel K'e falls under the South Slave Divisional Board of Education and offers kindergarten through grade 9.

The Rae-Edzo School Society was the first Aboriginal organization in Canada to take control of a community school. In 1994, the Chief Jimmy Bruneau High School in Edzo offered residence facilities for 12 students from smaller surrounding communities, and an additional 20 high school students were boarded out with families.

Table 4.2-16
First Nations Communities Inventory 1995

Item	Dettah/ N'dilo	Rae-Edzo	Rae Lakes	Wha Ti	Snare Lake	Lutsel K'e
Garage		2 bay	2 bay	2 bay		3 bay
Maintenance Garage		2 bay	2 bay	2 bay	2 bay	2 bay
Staff House		1	2	2		
Community Office	1 (Dettah)	1	1	1	1	1
Water Supply	Truck	Truck/ piped	Truck			Truck
Garbage Pick-up	Contracted	Truck	Truck	Truck		
Sewage Treatment	Lagoon	Lagoon			Lagoon	Lagoon
Solid Waste Disposal	Landfill	Landfill	Dump	Dump	Landfill	Landfill
Equipment - Roads	Contracted	Yes	Yes	Yes	Yes	Yes
Fire Equipment	Firehall	Firehall	Firehall	Fire truck	DC*	Fire truck
Gyms	1	2	1	1		1
Halls	1 each comm.	1 large		1 medium	1 small	1 very old
Arenas	Yellowknife	Arena				
Pools	Yellowknife	Pool				
Play Areas	Planned '97	Planned '97		Planned '97	Planned '98	Planned '97
Curling Rink	Yellowknife	Yes				
Health Centre	Stanton Hosp.	Yes	Yes	Yes		Yes
Care Centre	N'dilo	Elders				
Alcohol Program				Yes		Yes
Community Radio	Yes		Yes	Yes		
Telephones	Included in Yellowknife	412	74	106	n/a	n/a
Power	(Yellowknife) hydro/diesel	Hydro/ diesel	Diesel	Diesel	Diesel	Diesel
Road	Yes	Yes	Winter road	Winter road		
Air Services	Yellowknife		Twin otter	Twin otter	Twin otter	Twin otter

* DC: Dry chemical truck.
Sources: Outcrop 1990; NWT Transportation 1990, 1994; NWT Municipal and Community Affairs 1994a, 1994b, 1995d; NWT Power Corporation 1995b; Northland Utilities 1995; NWT Health and Social Services 1995b; NorthwesTel 1995.

Table 4.2-17
First Nations Communities
Preference for Homeownership or Rental

	Homeownership	Rental
Rae-Edzo	88%	11%
Rae Lakes	98%	2%
Wha Ti	96%	3%
Snare Lake	100%	-
Dettah	68%	27%
N'dilo	69%	31%
Lutsel K'e	76%	20%

Source: NWT Housing Corporation 1992.

Table 4.2-18
First Nations Communities
Housing Stock by Period of Construction

	Rae-Edzo	Rae Lakes	Wha Ti	Snare Lake	Dettah	N'dilo	Lutsel K'e
Before 1946	10	–	–	–	–	–	–
1946 to 1960	15	–	10	–	–	–	10
1961 to 1970	45	15	15	10	–	–	15
1971 to 1980	85	10	10	–	–	–	10
1981 to 1985	65	10	20	10	–	–	10
1986 to 1991	90	10	15	–	40*	42*	20
1992 to 1995 est.	46	11	18	10	–	17	n/a
Total	**356**	**56**	**88**	**30**	**–**	**59****	**65**
Ownership 1991	39%	80%	84%	100%	57%	N/A	42%
Core Need 1992	137/329	30/52	49/74	14/21	14/40	12/42	33/69
In Core Need/ Units Surveyed							

* Total 1992.
** Count 1995.
Source: Canada Census 1991b; NWT Housing Corporation 1992, 1995; Actual count 1995.

Table 4.2-19
First Nations Communities
Number of Households in Core Need
by Household Type 1992

	Families	**Extended Families**	**Senior/Singles/ Couples**	**Total Requirement**
Rae-Edzo	89	36	12	137
Rae Lakes	25	2	3	30
Wha Ti	32	9	8	49
Snare Lake	7	6	1	14
Dettah	10	4	-	14
N'dilo	5	2	5	12
Lutsel K'e	21	6	6	33
Total	**189/65%**	**65/22%**	**35/12%**	**289/100%**

Source: NWT Housing Corporation 1992.

The Board has a Student Support Services program, which provides encouragement, counselling, advocacy and intervention on behalf of students. The Chief Jimmy Bruneau School provides space for a volunteer-run Child Development Centre to provide day care for children of students. Student support staff are also involved in establishing peer group support for students with alcohol and drug problems. Grade 12 was added to the regional high school in 1994 (Dogrib Divisional Board 1994).

4.2.5.7 Health Facilities

The Aboriginal communities in the study area are part of the area served by Stanton Yellowknife Hospital. In 1995 Stanton estimated that more than 58% of patients were Aboriginal. The hospital has a full time Dogrib and full time Inuktitut interpreter on staff (Stanton Yellowknife Hospital 1995).

Locally, three of the four Dogrib communities and Lutsel K'e are served by Health Centres staffed by nurses. They provide ongoing health care programs as well as emergency treatment services. NWT capital plans call for the establishment of a health station in Snare Lake, with construction to start in 1996. Dettah and N'dilo are served by Yellowknife based health services.

4.2.5.8 Social Facilities

There are four government social services workers in Rae-Edzo and two (including a local trainee) in Wha Ti. They deliver all government social programs for the Dogrib communities, including social assistance, services to the handicapped, child welfare, family programs, and alcohol and drug programs. The Friendship Centre in Rae-Edzo is currently being re-organized, and social services workers are providing alcohol and drug referrals. Treatment is provided in Yellowknife, Hay River or southern Canada.

The Treaty 11 Council is suggesting that the Dogrib Divisional Board, which provides many similar services to its student population, should take over the combined education, employment and social services functions proposed by the newly re-organized NWT Department of Education, Culture and Employment.

4.2.5.9 Policing

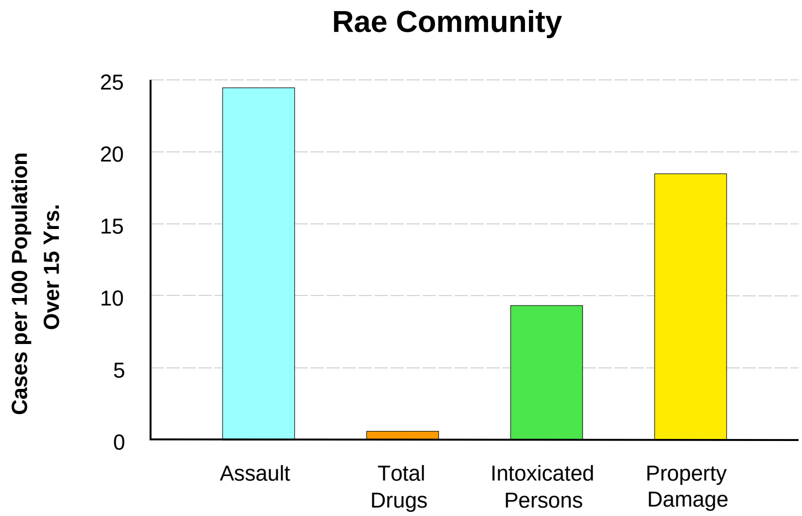
Policing for the Dogrib communities is headquartered in Rae-Edzo, with a seven man RCMP detachment. RCMP statistics of reported crimes dropped significantly in 1994 over 1993. This is apparently due more to workload than to a reduction in crime. Notable among the reported incidents is a decrease in offenses under the territorial liquor act. Liquor is prohibited as a result of a community decision in Wha Ti, Rae Lakes, Snare Lake and Lutsel K'e (NWT Liquor Commission 1994), but is still present in limited quantities and causes considerable community stress.

Figure 4.2-2 provides a comparison of the incidence community violence and abuse based on Rae RCMP cases for 1994. The population base is approximate. Column A, assault, and column D, property damage, show a high incidence of cases per 100 population over the age of 15 years. Rae has the second highest incidence of assault cases in the NWT Diamonds Project study communities, more than twice that of the study community with the next highest rate. Rae also has the highest incidence of property damage, largely break and enter and petty theft.

Figure 4.2-3 provides similar data for Lutsel K'e using approximate population figures. Again, assault and property damage cases are more prevalent than intoxication. Though Lutsel K'e has alcohol prohibition, it has the highest rate of drug-related RCMP cases of the NWT Diamonds Project study communities.

4.2.5.10 Commercial/Industrial Infrastructure

Community plans, prepared with the help of NWT Municipal and Community Affairs, provide for commercial and industrial zoning as well as residential. The hamlet of Rae-Edzo has the best potential to expand the business services offered and has a considerable area zoned for future commercial/industrial growth (UMA 1994). Rae currently has 32 businesses, over 90% of which are owned by the Dogrib. Thirteen of the 32 are engaged in some form of transportation or construction and eight are retail businesses (NWT Economic Development and Tourism 1995b and 1995c).



Population over 15: 1,148

NOTE: **Based on estimated population over 15 years of age, 1994.**

May not fairly represent community violence cases over a period of time.

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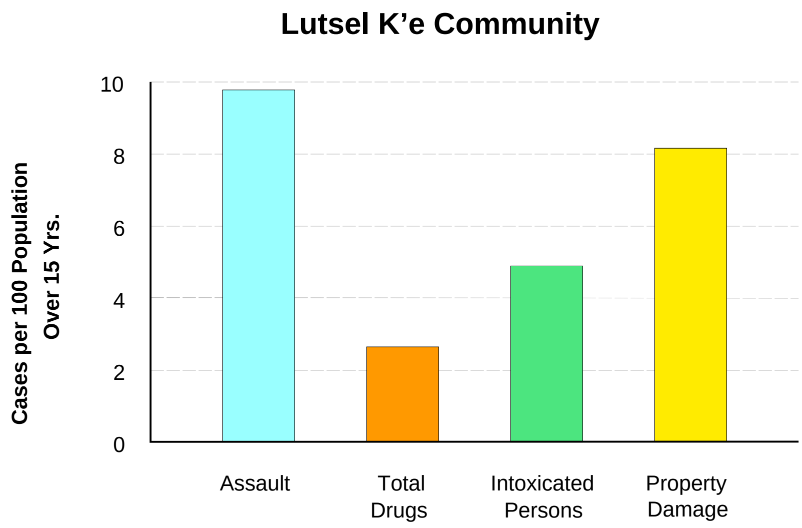
Figure 4.2-2
RCMP Statistics for 1994—
Rae Community

Source: RCMP Statistics for 1994



Population over 15: 223

NOTE: **Based on estimated population over 15 years of age, 1994.**

May not fairly represent community violence cases over a period of time.

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Figure 4.2-3
RCMP Statistics for 1994—
Lutsel K'e Community

Source: RCMP Statistics for 1994

In the smaller communities the local band development corporation is usually the parent company, which meets the development requirements of the community. Board members, therefore, may serve on both the band corporation board and that of an operating company such as the contracting service, the store or the hotel. This leadership is vitally important to the community.

Many First Nations groups are developing their own corporations, which they may own, partially own, or manage. These companies provide both income and employment for their respective communities. The companies are of different sizes and at different stages of development, from the idea stage to established businesses listed in Table 4.2-20.

Table 4.2-20
Types of Business in Dogrib Communities
and Dogrib Nation Joint Ventures

Dogrib Communities Businesses	Dogrib Nation Businesses
Forestry	Nishi/Khon Forest Services Ltd.
Construction	Nishi-Kohn/SNC Lavalin Ltd. Nishi-Kohn/PCL Constructors
Transportation	Nishi-Kohn/Canadian Helicopters Nishi-Kohn Freeway Inc.
Communications/Power	Dogrib Power
Building Supplies	
Food Stores	
Department Stores	
Business Services	
Outfitters	
Hotels	
Restaurants/Caterers	Tli cho Catering Ltd.

Source: Dogrib Nation 1993, 1995.

The interest that the different First Nations groups have in developing business opportunities is shown in the following quotes:

"First Nations' corporations are at the early stages of development and...our economies are just emerging. Many interesting opportunities for resident and southern, large and small businesses can present themselves for joint venture and partnerships..." (D. Beaulieu).

"Each of the Dogrib communities contains businesses which are ready to provide a variety of services to development projects in our territory...In our discussions with developers, we want to arrange for equity participation and for joint ventures with Dogrib Companies..." (T. Blondin).

"I am confident that mineral development is one of those forces that will be a significant factor shaping our future. The Metis will participate in it with their traditions of entrepreneurship and risk taking..." (G. Bohnet).

"More and more, we are running our own affairs in the Dogrib region. Our businesses are growing, and they have to – our children and grandchildren are depending on us. Our region has great potential for tourism, mining and power generation. We want to take part in this development, for the future of our land and young people" (Chief Joe Rabesca).

The first three excerpts are from speeches made at the conference called Staking New Partnerships, held in Yellowknife in November 1994. The last quote is from Chief Joe Rabesca of the Treaty 11 Dogrib. They offer insight into the level of interest Dene and Metis businesses have in any new project in the NWT. Table 4.2-20 provides a general indication of the types of businesses in the Dogrib communities and the joint ventures achieved so far by the Dogrib Nation Group of Companies.

4.2.6 Capacity for Growth

The NWT Government capital plan calls for an investment of some $7.2 million in community facilities in First Nations communities in fiscal year 1995/1996 and $5 million in 1996/1997. Investment includes residential land development in Rae-Edzo to provide a two year supply of lots, as well as sewage solid waste handling improvements and renovations to the high school. In Rae Lakes construction of an arena is planned for completion in 1998. Wha Ti will have a new well pumphouse completed in 1997 and an arena completed in 1996. Construction is under way in Snare Lake on a well pumphouse to be completed in 1997 and a new gym to be completed in 1996. Airport construction will continue and a health station will be started in 1996/1997. A new fire hall and community hall are underway in Lutsel K'e. This activity will provide significant improvements to all communities in the study area (Table 4.2-21) (NWT Financial Management Board Secretariat 1994; NWT Municipal and Community Affairs 1995d).

4.2.6.1 Planning/Capacity

The Hamlet of Rae-Edzo has a zoning by-law that designates a development officer to review development permits and includes a development appeal board process. Use of undeveloped areas requires the agreement of both the hamlet and the Dogrib Rae Band (UMA 1994). In the smaller communities, either the municipal government or the band council looks after these matters. Between running active businesses, managing the development corporations and negotiating land claims and services with various levels of government, the

Table 4.2-21
First Nations Communities
NWT Capital Plan
1995 to 1997

	Rae-Edzo	Rae Lakes	Wha Ti	Snare Lake	Dettah	Lutsel K'e	Total
Residential/ Commercial Land							
1995/1996	720,000	10,000	60,000	30,000			
1996/1997	575,000	60,000	60,000				
Water, Sewage, Solid Waste							
1995/1996	220,000		400,000	475,000	2,000	340,000	
1996/1997	10,000		500,000	336,000	140,000		
Other Facilities – Municipal							
1995/1996	120,000	200,000	686,000	510,000		525,000	
1996/1997	276,000	365,000	595,000	215,000		465,000	
Schools							
1995/1996	2,039,000						
1996/1997	1,071,000						
Health Facilities							
1995/1996				36,000			
1996/1997				410,000			
Airports							
1995/1996				900,000			
1996/1997				20,000			
Total Capital							
1995/1996	$3,099,000	$210,000	$1,146,000	$1,951,000	$ 2,000	$865,000	$7,273,000
1996/1997	$1,932,000	$425,000	$1,155,000	$ 981,000	$140,000	$465,000	$5,098,000

Source: NWT Financial Management Board 1994.

Dogrib and Yellowknives leadership was spread thin in 1994 and 1995. This difficulty is probably temporary and will be resolved as the issues associated with land claims are resolved and as the necessary management skills can be passed on to other members of the communities.

4.2.6.2 Education/Work Force

In 1994, an employment coordinator was seconded from the GNWT to the Treaty 11 Council to assist in encouraging local employment in mining and hydro-electric projects in the Dogrib region. An estimated 200 persons applied, roughly half of whom had some construction/mining experience. Approximately 60 applicants found full time or part time work in these industries.

In the study region, work force skills among the unemployed include skilled and intermediate transportation and equipment operators, clerks, intermediate sales and services, and trades helpers or construction laborers. Mine training, driver education and heavy equipment operation courses were offered by Arctic College West in 1994/1995 in the region (Lutra 1995).

4.2.6.3 Social/Leadership Resources

Several projects are under way in the Dogrib communities that give an indication of the social and leadership training opportunities. The Dogrib Divisional Board of Education has established a Dogrib Language Centre, which recently published a Dogrib-English dictionary and a grade 2 bilingual curriculum. Cultural programs are included in the school curriculum. Students go on a barren lands caribou hunt, go fishing and some run traplines each year. Several of the community schools offer Dene drumming programs, and the youth drummers have gained international recognition.

In Rae Lakes, a Traditional Government research project, started in 1993, is assisting the Dogrib to record their traditional system of government. The information will be used to develop a self government model and in school curricula (Dene Cultural Institute 1994a).

In Wha Ti, a project to document traditional knowledge on healing properties of plants and animal parts, started in 1992, has resulted in a comprehensive directory of information contributed by the elders. Researchers were trained on a previous project, which involved documenting Traditional Dene Justice, with assistance from the Dene Cultural Institute and the Arctic Institute. The Dene Justice project produced a recommendation that an intensive ongoing alcohol treatment program and healing circles be established to combat alcohol and other social problems. A second recommendation centred on the development of a community education program to discuss the Justice Project and come to a consensus on new directions for Dene Justice. The final recommendation suggested that a pilot project be set up to test old and new Dene ways of resolving conflicts and “crimes” in the community, and a Dene Justice Committee has been formed (Dene Cultural Institute 1993, 1994b).

4.3 Coppermine

Coppermine is approximately 400 km northwest of the NWT Diamonds Project site at the point where the Coppermine River empties into the Coronation Gulf (Figure 4-1). It is the only community on the Coppermine River system. The headwaters of the Coppermine River are at Lac de Gras adjacent to the proposed NWT Diamonds Project.

Coppermine is the second largest community in the NWT's Kitikmeot Region and was likely a seasonal Inuit fishing and sealing camp from very early times. The Inuit at this location also spent part of each year inland, hunting caribou. The community's Inuit name is Kugluktuk, which means "a place of rapids," likely referring to Bloody Falls, just up-river from Coppermine.

In 1769, the Hudson's Bay Company sent Samuel Hearne to the area to discover the source of copper brought to Fort Prince of Wales (on Hudson Bay). He reached the mouth of the river and named it the Coppermine in July 1771. The traditional lifestyle of the Inuit in the Coppermine area was studied and recorded by Diamond Jenness, an ethnologist with the Canadian Arctic Expedition from 1913 to 1916.

The way of life for the Copper Inuit began to change in 1916 when the independent trader Charles Klengenberg set up a post. By this time the inland caribou herds had started to decline and the people who lived at many different points inland began to spend more time near the coast, trapping and hunting sea mammals.

The development of the community was relatively rapid after 1916. In 1927 the Hudson's Bay Company established a post and in 1928 the Anglican mission was built. Influenza killed over half the Inuit at Bernard Harbour (112 km northeast) and the survivors fled to Coppermine, where a hospital was temporarily established in 1929.

The RCMP arrived in 1932 and by 1937 Coppermine had a weather station and radio facilities. The nursing station was opened in 1948. In 1959, when many Inuit across the Arctic were just beginning to settle permanently in small communities, usually around trading posts or churches, Coppermine was opening its first school (Outcrop 1990).

Coppermine residents were introduced to rotational employment at non-renewable resource sites during the oil and gas exploration boom in the Mackenzie Delta/Beaufort Sea area during the 1970s. A substantial number of residents took advantage of training and employment opportunities offered by the companies involved in the exploration. During the winter of 1972/1973, 54 Inuit from Coppermine worked for varying lengths of time in the Mackenzie Delta for contractors of Gulf Oil Canada. They worked 14 days, and occasionally up to 21 days, without a break, then were flown back to Coppermine for a seven day rest period. They generally worked 12 hours per day.

"There can be no doubt that the overall effect of the employment program on the settlement of Coppermine was highly favorable. Many men who would otherwise have been unemployed had an opportunity to work. The flow of cash into the community was very substantially increased, by about 75%, we estimate. These funds enabled the people of the community to purchase more needed equipment,

more and better clothing, as well as more luxuries and more liquor, and to pay higher house rents and some of them, higher income taxes" (Hobart 1994).

When the Beaufort exploration closed down in the early 1980s, there was a substantial decline in total community income, but this was partially made up with the opening of the Lupin Gold Mine and the hiring of Coppermine residents to work there on a rotational basis. In March 1995, 40 Coppermine residents were working at Lupin on a two weeks in/two weeks out rotation. Almost all have been with the mine for over a year, and some have worked there for five to 15 years (Lupin 1995).

To add jobs and economic activity to the growing community, some regional offices of GNWT departments, previously located in Cambridge Bay, were moved to Coppermine in the early 1990s. The residential and commercial needs of this group caused a mini construction boom, boosted employment in the local economy and started a private market for housing and commercial office buildings. Recent moves to Coppermine of some staff of the regional Kitikmeot Inuit Association are also assisting the local economy.

4.3.1 People/Demographic Profile

The population of Coppermine in 1991 (Canada Census 1991b) was 1,060, a 20% increase from five years earlier. The NWT Municipal and Community Affairs (1994a) estimates the 1994 population at 1,180, and the NWT Bureau of Statistics (1993) estimates the 1996 population will be 1,210, rising to 1,512 by 2006. The majority of Coppermine's population is Inuit (92%), close to 40% of the population is 14 years or younger and there are slightly more females than males in the community (Table 4.3-1).

Table 4.3-1
Coppermine Population by Sex and Age
1991

	Total	0 - 14 Years	15 - 24 Years	25 - 44 Years	45 - 64 Years	65+ Years
Males	510	190	90	150	55	25
Females	550	210	110	160	55	20
Total	**1,060**	**405**	**195**	**320**	**110**	**35**

Numbers do not add due to rounding by Census Canada.
Source: Canada Census 1991b.

Nearly 87% of the total population is under 45 and nearly half of the total population is in the 15 to 44 age category. Nearly half of the population over 15 have less than grade 9 education, while 25% have a trade designation, diploma or degree (Table 4.3-2). It would appear that residents of the community are becoming more aware of the need for an education, indicated by the increase in voluntary enrollment in Arctic College education upgrading programs (G. Bolduc, Arctic College pers. comm.).

Table 4.3-2
Coppermine Education Levels
1991

	Total	Males	Females
Population 15 Years and Over	655	320	340
Less than Grade 9	330	140	190
Grade 9 to 13 without Secondary Certificate	95	50	50
Grade 9 to 13 with Secondary Certificate	20	-	10
Trades Certificate or Diploma Only	20	15	10
Some University or Non-university without Diploma	55	35	20
University or Non-university with Diploma	110	65	45
University Degree	25	10	15

Numbers do not add due to rounding by Census Canada.
Source: Canada Census 1991b.

Of the 155 people in Coppermine having a post-secondary education certificate, diploma or degree, 90 are males and 65 are females.

About 44% of the adult population is single. Although 90% of the census respondents indicated they speak their Aboriginal language, a large proportion of these people speak English as well.

With a high percentage of young people in Coppermine and limited economic activity, jobs are difficult to find (Outcrop 1995). Community unemployment is 31%, substantially higher than the territorial unemployment rate of 17% or the Kitikmeot region unemployment rate of 23% (NWT Bureau of Statistics 1994a). Unemployment in the Coppermine Aboriginal population is 38% compared to an unemployment rate of 30% for the total territorial Aboriginal population.

In Table 4.3-3, it is interesting to note that the participation rate in the labour force is only 54%, substantially lower than the territorial rate of 73% or the Kitikmeot Region rate of 62%. This likely accounts for the fact that although the number of unemployed is listed at 120, the number of people who claim to want a job is 292, or more than double the number unemployed. This indicates there is likely a large potential labour force in Coppermine who would seek wage employment if they had the qualifications or if employment was available.

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Table 4.3-3
Coppermine Labour Force
1994

	Persons 15 Years & Over	Labour Force	Participation Rate	Employed	Unemployed	Unemployment Rate	Want A Job	Worked in 1993
Aboriginal	613	302	49%	186	116	38%	n/a	n/a
Non-aboriginal	97	81	84%	77	4	4%	n/a	n/a
Total	**710**	**383**	**54%**	**263**	**120**	**31%**	**292**	**413**

Source: NWT Bureau of Statistics 1994a.

Approximately 75% of the population have lived in Coppermine all their life while 23% have lived elsewhere in the Northwest Territories and 2% elsewhere in Canada (Canada Census 1991b).

4.3.1.1 Employment

In 1994, there were 263 jobs in Coppermine. Of these, 39% were in management, office occupations or science, health, education and government. Another 28% were in sales and service occupations and 24% were trades or semi-skilled occupations (NWT Bureau of Statistics 1994a). Unskilled workers could take 25% of the jobs and another 20% require some training or education (Table 4.3-4).

Table 4.3-4
Employment by National Occupation Classification
Coppermine 1994

	Number	Percentage
Management, Skilled Office, Clerical	47	18%
Sciences, Health, Education, Government	55	21%
Arts, Culture, Recreation, Sport	5	2%
Sales and Service	74	28%
Trades, Skilled, Semi-skilled	52	20%
Producing, Manufacturing	10	4%
Unaccounted	20	7%
Total	**263**	**100%**

Source: NWT Bureau of Statistics 1995c.

4.3.2 Economic Activity/Sectors

4.3.2.1 Government

Government accounts for nearly half the jobs in Coppermine (Table 4.3-5). Within this sector, education makes up 19%, while health care workers make up 13%. The balance includes territorial and municipal government employees.

Government jobs appear to be highly regarded within the community, particularly for their pay rates, housing benefits and status, and are the goal of many people seeking employment.

The territorial government moved its regional offices of Education, Social Services and Renewable Resources to Coppermine within the past five years.

Table 4.3-5
Coppermine Labour Force by Occupation/Income
1991

	Employment % per Sector	Income % per Sector
Public Administration, Health and Education	42%	44%
Transportation/Communications/Construction	17%	20%
Retail/Accommodation/Food Service	15%	9%
Mining, Manufacturing	10%	14%
Finance/Businesses/Other Services	9%	9%
Renewable Resources*	6%	3%
Total	**99%**	**99%**

* Arts and crafts producers are included under Renewable Resources.
Source: Canada Census 1991b.

It also has representatives of several other departments in Coppermine. The municipal government oversees regular community services, including recreation, and is also responsible for the community's employment officer, who handles unemployment insurance commission applications and payments as well as other duties in the community.

With the completion of a new school in 1995 and the expansion of high school grades within the community, the number of employees in the education sector will increase, in line with both expanded facilities and the growing school enrollment in the community. The NWT Education reports a 17% increase in enrollment from 327 in 1992 to 383 in 1994 (NWT Economic Development and Tourism 1994).

4.3.2.2 Retail/Accommodation/Food Service

After Public Administration, retail is the single largest employer in the community. In Coppermine there are two major retail outlets, the Northern Store and the Co-op, which provide most of the food, household and personal goods to the residents of Coppermine. There are few if any smaller retailers in Coppermine and it is unlikely the population could sustain another major retailer.

There is one hotel (capacity 27) and two bed and breakfast facilities in Coppermine. Meals are available only for guests at these facilities, and a coffee shop and bakery are considered potential business opportunities in Coppermine (NWT Economic Development and Tourism 1993). Tourism is limited in Coppermine, although recent studies have identified areas of potential development. The main tourism activity is in sports hunting, via a joint venture between the local Hunters and Trappers Organization (HTO) and a non-aboriginal businessman. The HTO is involved in a barren ground caribou sport hunting operation on Lac de Gras and reported that it did not operate last year, depriving some Coppermine guides of part time income. The community also provides some general touring opportunities and, as the terminus of Coppermine River canoe and raft expeditions, sees many pass-through visitors at the end of their trips. There are no current statistics to determine the visitation levels to the community.

4.3.2.3 Transportation/Communications/Construction

Transportation to Coppermine is mainly by air, although dry goods and bulky materials, including building materials, are brought in by sealift each summer.

Three regional airlines have regularly scheduled air service into Coppermine, providing the community with daily connections to Yellowknife and southern Canada and with other communities in the Kitikmeot. The 737 jet service returned to Coppermine with the recent upgrading of the runway facilities. No charter aircraft are stationed at Coppermine, although the regional airlines do have agents in the community.

Goods bound for Coppermine via water routes start their journey in Hay River and are carried on barges down the Mackenzie River to Tuktoyaktuk for trans-shipping along the Arctic Coast. Water resupply to communities continues to be supervised by the government. The company providing water resupply is Northern Transportation Company Limited.

Two construction/contracting companies operate almost exclusively in the local market. They complete site work, lease heavy equipment, construct buildings and provide general trades services. The level of activity for these companies is closely tied to the government's capital expenditures on infrastructure in the community.

Transportation, communications and construction represent 16% of Coppermine's employment.

4.3.2.4 Mining/Manufacturing

Mining and manufacturing account for 13% of Coppermine employment. The major supplier of jobs in this sector is Lupin Mine, which had 40 Coppermine residents on its payroll as of March 1995 (Lupin 1995). Seasonal exploration jobs are also available, with more than 50 people involved in an exploration program operating out of Coppermine in 1994. There is regional potential for gold, silver and diamonds as well as base metals, especially lead/zinc at the Izok Lake project, which is currently on hold.

Manufacturing involves many of the part time workers in the crafts and clothing industry. Much of the work done in this industry is piece work, but sales of goods, especially sealskin hangings, bring outside dollars into the community.

4.3.2.5 Finance/Other Business/Personal Services

There are no financial services available in Coppermine. Banking is done at major centres, and business services including accounting, legal, investment, etc. are generally purchased in Yellowknife or at other southern centres. Also, there are few personal service businesses, thus, this sector accounts for only 9% of total work force. It includes such businesses as a travel agency, taxi service, property management and local freighting and deliveries.

4.3.2.6 Renewable Resources

Over half the adult (over 15 years of age) population of Coppermine is involved in Coppermine's traditional economy on a full time or part time basis. In 1993, 398 people hunted and 52 people were involved in trapping. In 1994 the number involved in trapping had dropped to 41. The average trapping income in 1994 was $1,202. Main species trapped were white fox (733 for an income of $17,029) and wolf (81 for an income of $25,948) (NWT Bureau of Statistics 1994e; NWT Renewable Resources 1995). Other animals hunted by Coppermine residents include muskox, polar bear, moose, barren ground grizzly bear, ring seal and harbour seal.

Products from hunting and trapping are also used in arts and crafts production, with 218 people involved in this area of the economy.

People of Coppermine hunt both the Bathurst caribou herd and the smaller coastal caribou found along the coast and on the islands (not the smaller Parry caribou). For the Bathurst caribou herd the General Hunting Licence (GHL) maximum harvest since 1980 was 225. The commercial meat quota in 1992/1993 was 214 and the HTO (Class B Outfitters) quota was 100 animals (NWT Renewable Resources 1994a).

A meat and/or fish plant, or expansion of the present Hunters and Trappers operation, was proposed as a desirable project in the Business Identification Study of the Kitikmeot Region (NWT Economic Development and Tourism 1993). It was suggested that a larger meat plant similar to the facility in Cambridge Bay would be viable in Coppermine. A large part of the population also fish for food. A small commercial fishery for Arctic char landed 600 kg with a value of $2,300 in 1993/1994 (Fisheries and Oceans Canada 1993). The fishery's quota for char in 1993 for commercial licence holders was about 2,400 kg. This commercial quota is being phased out, as subsistence fishing is taking a major portion of available fish (Department of Fisheries and Oceans Canada 1994, 1995a, 1995b).

4.3.3 Income

The average income for full time and part time employment in Coppermine in 1992 was $20,226, up almost 14% from the previous year (NWT Bureau of Statistics

1994b). Although this is lower than the Canadian average, it appears to be increasing as more higher-income civil servant positions are moved to the community.

Although there has been an increase in the overall income over the past three years, it is likely that the percentage change in income levels per individuals and households has not changed substantially (Tables 4.3-6 and 4.3-7).

Table 4.3-6
Coppermine Population 15 Years and Over with Income by Income Group

Income	Percentage
Under $10,000	51%
$10,000 - $20,000	16%
$20,000 - $30,000	9%
$30,000 - $50,000	15%
Over $50,000	8%

Canada Census 1991b.

Table 4.3-7
Private Households by Income Group

Income	Percentage
Under $10,000	10%
$10,000 - $20,000	25%
$20,000 - $30,000	15%
$30,000 - $40,000	9%
$40,000 - $50,000	13%
Over $50,000	27%

Canada Census 1991b.

4.3.3.1 Other Income

Over the past five years social assistance payments have decreased over 80% in Coppermine from a high of $947,373 in 1989/1990 to $518,314 in 1993/1994. In the same period the number of social assistance cases dropped from 259 to 166 (NWT Economic Development and Tourism 1994).

The largest amount of social assistance, 21%, was paid in the “income subsidy” category to people who do earn limited income but require additional assistance to meet their needs (Table 4.3-8). The combined groupings of “no jobs” and “not working" required 26% of the social assistance payments, while single parents received 18% of the total payments in Coppermine in 1994 (Table 4.3-8). In total, 44% of social assistance payments are related to a lack of employment income in Coppermine. Approximately 40% of the 1993/1994 recipients of social assistance in Coppermine were in the 25 to 34 age category (Table 4.3-9).

Table 4.3-8
Coppermine Social Assistance by Need
1993 to 1994

Employability	Total ($)
Aged	$ 8,991
Harvester	2,180
Income Subsidy	107,238
Medical	43,302
No Jobs	84,698
Not Working	45,801
Self-employed	5,010
Single Parent	92,967
Social	59,765
Student	17,208
Transient	1,030
Other	43,473
Total	**$ 511,663**

Source: NWT Health and Social Services 1995a.

Table 4.3-9
Coppermine Social Assistance by Age Groups
1993 to 1994

Age	Total
0 to 17	$ 1,589
18 to 24	87,914
25 to 34	209,674
35 to 44	55,214
45 to 59	104,124
60 to 64	54,846
65 and over	5,091
Total	**$ 516,252**

Source: NWT Health and Social Services 1995a.Cost of Living.

4.3.3.2 Cost of Living

The cost of living in Coppermine is 40% higher than in Yellowknife and 70% to 75% higher than in Edmonton (NWT Bureau of Statistics Canada 1995c). The fact that almost all goods and food products have to be imported from southern Canada adds considerably to the cost of everything from housing and heating fuel to basic groceries. Food prices in Coppermine are estimated to be 52% higher than in Yellowknife, and a food basket for a family of four was estimated at $231 per week in 1991 (NWT Bureau of Statistics 1995c).

4.3.4 Infrastructure

4.3.4.1 Transportation

Coppermine has a 1,524 m long gravel runway, which can accommodate 737 jets as well as a range of smaller planes. The airport is operated by the hamlet and includes an air terminal building with 24 hour weather, communications and flight planning service (NWT Transportation 1990). Shipping service is provided during the short summer season via NTCL from its transshipment point at Tuktoyaktuk. There are no road links from Coppermine to other NWT communities. In conjunction with the proposed Izok Lake lead zinc mine, a road from the mine to the coast near Coppermine was discussed, as was an extended shipping season port facility. This project is currently on hold, pending discussions on the development of the required transportation infrastructure and increases in world demand/prices for the minerals.

4.3.4.2 Municipal Government

Coppermine was granted hamlet status by the territorial government in 1981. It is governed by an elected mayor and eight elected councillors. The hamlet of Coppermine ended its fiscal year 1993/1994 with excess revenue of $124,000. Revenues of $1.2 million were made up of an operating grant from the GNWT of $714,000 and other revenue of nearly a half million dollars. Other revenue included a number of smaller grants for various programs (facilities grant, aquatics grant) and a collection of permit, licence, user and rental fees (NWT Municipal and Community Affairs 1995a). Coppermine is not a tax based municipality and therefore does not collect property tax from residents.

4.3.4.3 Municipal Services

The hamlet provides or contracts out water and sewage services, road maintenance and maintenance of the airport. The hamlet is also responsible for waste pickup and disposal.

The hamlet has an arena, as well as playgrounds, a community hall and curling. The school gym and sports field are also used by the community. The Coppermine community library is part of the NWT Library system.

Power is supplied by a diesel power station operated by the NWT Power Corporation. Fuel for power generation, heating and equipment requirements is resupplied by barge from Hay River once a year.

The GNWT provides health care at a four bed community health centre staffed by nurses. A dental therapist and visiting dentists provide dental care.

The Coppermine Education Council provides classes from kindergarten to grade 12 at the Kugluktuk School. School enrollment has increased from 327 in 1992 to 383 in 1994. A new school to replace the existing one is scheduled to open in 1995.

Coppermine has direct dial telephone service via satellite, provided by NorthwesTel Inc.

4.3.4.4 Housing/Home Ownership

In 1991 Coppermine had 260 dwellings, with 175 single detached homes (Canada Census 1991b). Of the total housing supply, 20 were privately owned, while the rest were rented, mainly from the local housing association. Since the 1991 Census, more private development has taken place in Coppermine, with developers providing rental units to both government and the open market. More than half the dwellings existing in Coppermine in 1991 were built before 1971.

A total of 108 of the 261 households in Coppermine were identified as in "Core Need" according to the NWT Housing Needs Survey, NWT Housing Corporation, 1992 (Table 4.3-10). Core Need was determined by suitability, affordability, adequacy or a combination of any of these factors.

Table 4.3-10
Number and Percentage of Households in Core Need by Household Type

Household	Number	Percentage
Families	74	68%
Extended Families	30	28%
Seniors	3	3%
Couples	1	1%

Source: NWT Housing Corporation 1992.

Of this group, 24% of households indicated a preference for home ownership, 52% preferred rental accommodation and the balance indicated no preference.

Rents for public housing are set by the NWT Housing Corporation and administered by the local housing association. Effective April 1, 1995, a new rent scale for social housing went into effect whereby rents are set in line with total household assessable income. Rent increases will be phased in over four years. The strategy of the rental increases is to move high income tenants from social (rental) housing into home ownership so that rental units are made available to low income families (NWT Housing Corporation 1994).

The supply of serviced lots in the community is limited, as are houses. People moving to Coppermine to jobs that do not provide housing or to be closer to family often have to live with family until a house becomes available.

4.3.4.5 Social Facilities

Apart from government directed programs, Coppermine has a limited number of community-sponsored, volunteer agencies to assist in concern areas such as substance abuse, physical abuse, physical disabilities, physical and mental health problems. Some territorial agencies (Mental Health Association, Council for the Disabled, Crimestoppers) do service the community and, in some cases, offer 1-800 numbers to their Yellowknife based services.

At the same time, authorities involved with the community's social stability state that problems such as drug and alcohol abuse and physical abuse are prevalent in the community. In some cases people interviewed indicated a direct relationship between an increase in income and an increase in alcohol, drug and physical abuse (Asels 1995).

Two churches operate in the community (Anglican and Catholic).

Apart from care giving organizations, there are a number of other organizations in Coppermine that assist in improving the social fabric of the community. These include the Boy Scout and Girl Guide movement, army cadets, Canadian Rangers, organized hockey and softball leagues, church committees and a local chamber of commerce.

Government sponsored social facilities include an Awareness Centre (drug and alcohol abuse), a youth justice committee, the NWT Courtworkers program and a crisis shelter.

Several people in Coppermine, including hamlet council members, mentioned the problems with rotational workers being away from home. They indicated that miscommunication between husband and wife sometimes caused the problems and they suggested that perhaps the people left behind in the community need some kind of support group (Asels 1995).

Alcohol and drug abuse and suicides among young people are social problems repeatedly mentioned in interactions with communities (Volume IV, Section 4.1).

4.3.4.6 Protection Services

A three-officer RCMP detachment headed by a Corporal is responsible for policing services in Coppermine. They operate from a small office (soon to be enlarged), which has several holding cells for temporary use. Persons convicted of crimes who receive prison sentences are generally detained at the correctional centre in Yellowknife.

Crime rates in Coppermine (by total number of crimes committed) rank number 10 in the Northwest Territories, although Coppermine ranks number 15 by population size. Most crime is alcohol related, and violent crime is highest among males in their 20s, who are often unemployed or casual workers. Crime is lower among people with full time jobs, since these people generally want to stay out of jail and keep their jobs (Asels 1995).

Coppermine RCMP showed concern over lack of parental supervision in Coppermine and said that although there is a curfew for minors, some people pay fines regularly because their children are out after the curfew.

Criminal code charges against persons (homicide, assaults) increased 14% from 1993 to 1994, while criminal code charges against property decreased by 22%. Narcotics charges were up slightly, with marijuana possession the main charge, although there were a few charges of marijuana trafficking.

Total number of charges under territorial acts (excluding traffic) were down in 1994 over 1993 although there was an increase in the intoxicated persons category. There is no retail sales outlet for alcohol in Coppermine but it is possible to order alcohol from Yellowknife. Where possible, RCMP monitor supplies coming in via air freight.

Overall statistics show a small decline in the number of charges from 1993 to 1994 (RCMP “G” Division 1995b).

Figure 4.3-1 provides a comparison of the incidence of community violence and abuse, based on RCMP cases for 1994 in Coppermine and three small Alberta communities. Population bases are approximate. Coppermine has a very high rate of assault, measured as cases per 100 population over the age of 15. Coppermine has the second highest rate of drug cases per 100 population of the NWT Diamonds Project study communities.

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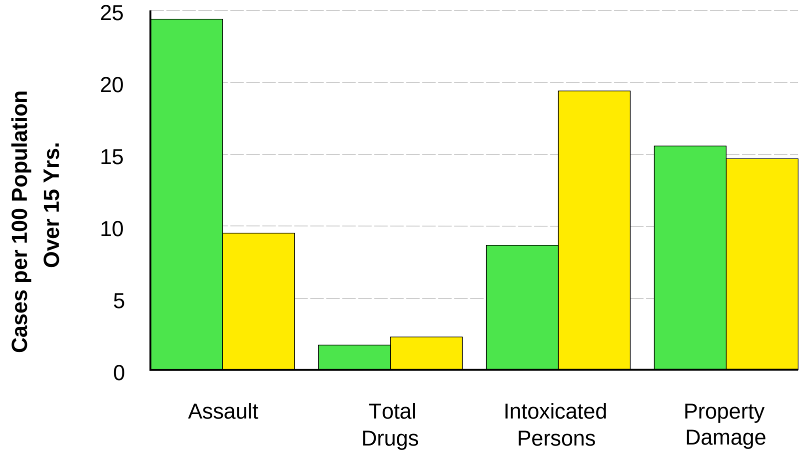
Coppermine vs. Small Alberta Communities



Coppermine

Population over 15: 710

Small Alberta Communities (Fort Vermilion, Fort Chipewyan, Lac La Biche)

Population over 15: 1120

NOTE: **Based on estimated population over 15 years of age, 1994.**

May not fairly represent community violence cases over a period of time.

NWT DIAMONDS PROJECT

Figure 4.3-1
RCMP Statistics for 1994—
Coppermine/Small AB Comm.

Source: RCMP "G" Division 1995 b

Property damage cases, largely break and enter and petty theft, also rate second highest of the NWT study communities.

Although intoxication cases suggest alcohol is a serious problem in Coppermine, the comparison with small Alberta communities indicates a less severe problem than in some southern hamlets of similar size.

Although not an offense, the RCMP indicated some concern over the amount of gambling in the community. RCMP indicated the stakes can be quite high, and losses can lead to family hardships and to crimes such as break and enter and assault.

Both the RCMP and the hamlet council expressed concern that drugs were getting into the community via rotational workers who were able to get them at work sites away from the community and bring them into the community.

In addition to a policing service, Coppermine has a fire department with one truck staffed by volunteer firefighters.

4.3.4.7 Financial Resources

Tasks such as land development, road development and water supply are financed by the GNWT as part of their capital expenditures in communities. GNWT planned expenditures in the 1995/1996 year include development of residential land, development work on water supply facilities, a new elementary school renovations to the existing school and completion of airport improvements, for a total of $4.673 million (Table 4.3-11). In 1996/1997 a total of $1.959 million in expenditures is planned (NWT Financial Management Board Secretariat 1994).

Table 4.3-11
Coppermine GNWT Capital Plan
1995 to 1997

	1995/1996	1996/1997
Residential/ Commercial Land	$100,000	$375,000
Water Sewage Solid Waste	130,000	902,000
Schools	3,243,000	682,000
Airports	1,200,000	-
Total	**$4,673,000**	**$1,959,000**

Source: NWT Financial Management Board Secretariat 1994.

4.3.5 Capacity for Growth

Small communities in the north usually base their community planning on expected population growth from within the community. They also consider outside factors that may effect growth, but these are usually limited to government decentralization and devolution programs (moving service delivery to different communities, or giving communities themselves responsibility for delivering certain services). Occasionally they engineer changes to the community to spur growth (making a community into a transportation hub), but in general they do not consider major projects as part of the development scenario unless they are scheduled in or near the community.

Coppermine has experienced some growth due to decentralization of both government and Kitikmeot Inuit Association positions to Coppermine. If the Izok Lake project and related port facility near Coppermine proceed in the future, Coppermine will have to prepare for substantial change. In the meantime, the hamlet and the GNWT, which funds much of the development in small communities, is looking at population growth of about 28% over the next ten years. Table 4.3-12 lists existing facilities in Coppermine and plans to update these facilities to accommodate the projected growth.

4.3.5.1 Work Force

Based on 1991 population statistics, the number of people of work force age in Coppermine is estimated to grow by some 300 persons from 710 in 1994 to over 1,000 (assuming little out-migration) in the year 2000 (NWT Bureau of Statistics 1993). Currently 263 people of work force age in Coppermine are employed (NWT Bureau of Statistics 1994a). Although some of the 300 people reaching work force age in the next five years will choose to stay in school, others will be looking for jobs in a limited job market. If they are unable to find jobs in Coppermine, it is likely they will have to either choose to work away from their home community on some type of rotational basis, or move to another community where work is available.

4.3.5.2 Social/Leadership Resources

The Coppermine respondents to a community satisfaction questionnaire listed lack of jobs and alcohol and drug abuse as the major problems faced by the community. As well, some community residents felt that more money coming into the community in wage employment from mining would add to the alcohol and drug problem.

Although Coppermine residents have identified major social problems in the community, it would appear that they are still grappling with potential solutions to these problems.

Table 4.3-12
Coppermine Community Facilities

Facility	Current Capacity/Use	Future Requirements
Schools		
Kugluktak School		Renovate 1995
Elementary School		New 1995/1996
Health Centre	4 bed	
Police Services	3 man	
Firefighting	New firehall, 1 truck	
Arena	Large	
Curling	2 sheets	
Playing Fields	N/A	Planned
Community Centre	Leased	
Gymnasium	Small	
Community Hall	Large	
Residential Lots		Estimated $15,000 development cost
Library		
Power	Diesel	
Water	Truck delivery	New supply system 1995
Sewage Facilities	Lagoon	
Solid Waste	Modified landfill	
Community Garages	3 units	

Source: NWT Municipal and Community Affairs 1994a, 1994b, 1995d.

4.3.6 Outlook

4.3.6.1 Community Survey

Community attitudes were determined to some degree from a brief questionnaire answered by 5% of the labour force age population (Outcrop 1995). In line with demographics, nearly half of the respondents were in the 25 to 44 age group and most were Inuit.

Of the respondents, 29% had full time jobs, 34% had part time jobs and the balance were either unemployed or not in the labour force.

Some of the findings from this survey are discussed below.

Almost all residents like living in Coppermine. Most often mentioned reasons for liking the community were the people there, the hunting in the area and the fact that family were close by. Most also wanted their children to grow up in Coppermine.

Most of the things people disliked about Coppermine centred on social issues and included alcohol/drinking/drug abuse, suicide and spousal abuse/violence. Much lower in the ranking were high travel costs and people moving in from out of town.

Sixty-three percent of respondents felt the community services in Coppermine were adequate, although a number of additional services were itemized. Most of the services people thought were needed related to the social requirements of the community and included a psychologist, more recreation events, a doctor, day care, marriage counselling, family counselling, a women’s shelter and programs for the abused. On the economic side, additional services mentioned included a bank, a restaurant and a charter airline.

Most people felt they were able to obtain most items they required, but on the list of goods they would like to be more available were parts (assume snowmobile or vehicle), furniture, cheaper food and more variety of goods.

Just over 30% felt they had enough money (possibly in line with the 29% who stated they had full time jobs) while the balance felt they did not have enough money to meet their needs.

If they had more money, respondents said they would use it a variety of ways. In order of ranking, here is how they would use additional money:

1. Save it
2. Pay bills
3. Buy a new snowmachine
4. Spend it
5. Buy groceries.

The concepts of saving money, which includes Registered Retirement Savings Plans (RRSPs), and providing local schooling for children are relatively new ideas in the NWT. It likely reflects both the community experience with wage employment in the past, as well as exposure to North American television.

Close to 85% of the people who have full time or part time jobs responded that they liked their job, primarily because of the people they worked with and the money. Several commented that they wanted more work, more hours or more jobs. The majority of respondents said it is very difficult or fairly difficult to get a job in Coppermine. Fifteen percent of respondents added that you needed education or skills to get a job.

Seventy percent of respondents said they still hunted and fished for food. Frequency of hunting and fishing ranged from once a week or weekends and holidays, to twice a month or as food is needed. Three-quarters of respondents said they hunted and fished less often than they once did.

One-quarter of survey respondents said they were aware of the NWT Diamonds Project, but only six respondents said they had ever been to the Lac de Gras area. Of the six who had been there, four said it was for hunting and trapping, one used to live in that area and one listed a visit with parents.

When asked if a diamond mine will have an effect on their use of the land, 26% said they didn't know, while 28% said there would be no impacts. Some members of the group responding believe that there would be no negative impacts and added that jobs were needed now. Twenty percent of respondents said a mine would affect the animals, and a few commented on garbage, pollution and road traffic.

The majority of respondents felt the mine would have an effect on their community. The top impacts, listed in order of ranking, were as follows:

1. Will offer jobs

2. More drugs and alcohol

3. Increased activity and business

4. Provide needed money

5. More traffic and transients in the community.

Other responses included comments such as increased family violence, more toys but not improved lifestyle, more pride and a goal to work towards.

Fifty-one percent of respondents said they would be interested in working at the NWT Diamonds mine, 35% said they would not be interested in working there and 14% expressed uncertainty about working there.

In summary, the survey shows a community that is highly aware of both its need for jobs and its need to come to grips with social problems. The majority of the population continue to rely on the land to some degree for food and are concerned about any disruptions to this food supply.

The population appears to have a good appreciation for wage income and what it can provide, but residents are also concerned about the additional alcohol and drugs they think will come into the community if there is more money available.

4.3.6.2 Potential to Benefit from the NWT Diamonds Project

Coppermine's population of labour force age is growing much faster than the local job market. Jobs are limited in the community, particularly for individuals at the low end of the education/skill levels; however, there appears to be a growing recognition of the need for more education and skills in order to get a full time job. The recent addition of high school grades in Coppermine as well as high participation in Arctic College educational upgrading programs should lead to improvement of overall education levels in the community.

Coppermine residents, both male and female, should be able to take advantage of direct employment at the mine, particularly since the Proponent plans to use Coppermine as a hiring point (transportation paid to site).

Although Coppermine's service sector is limited, there is also some potential for spin-off employment with local companies or with companies who are doing contract work for the mine, such as Nuna Logistics, which has completed a number of major contracts at the mine site.

Business investment and increased business in the community due to the NWT Diamonds Project would result mainly from the spending of employees' incomes within the community.

With its long history of involvement with rotational work, Coppermine residents are well-positioned to take advantage of project employment. Whether or not they can meet the employment requirements will depend on the initiative of labour force participants to obtain educational upgrading, to participate in training programs and to set goals and work towards them.

4.4 Yellowknife

Yellowknife is located on the north shore of Great Slave Lake, approximately 300 km southwest of the proposed NWT Diamonds Project. Yellowknife is the capital of the Northwest Territories and its largest community. It is connected by road to Rae-Edzo, Hay River and Edmonton. There is also a seasonal water transportation link with Hay River. Dettah and N'dilo are independent Dene communities on the perimeter of the city that exchange goods and services with Yellowknife.

Yellowknife's economic and social life has been dominated for more than 60 years by gold mining and, more recently, by the centralization of northern federal and territorial governments. Gold was first discovered at Yellowknife in 1934 by a geologist working for the federal governments. His discovery led to a staking rush, dozens of small mining ventures and the North's longest lived mine, the Con. By 1948, a small dam and power station on the Yellowknife River system began to supply hydro-power to the mines and the town growing around them. The mines, at opposite ends of the community, provided the impetus for continued growth and, until the 1970s, the stability required for the development of a small business sector. The Con Mine is still producing gold, and recent exploration has prolonged its life. Giant Mine started production in 1946 and poured its 10,000th gold brick in the late 1980s.

Yellowknife was named the capital of the NWT in 1967, the same year the NWT government administration moved there from Ottawa. The business community responded quickly to the demand for accommodation, and a number of apartment buildings and office towers were constructed. The Northwest Territories Legislative Assembly convened the first fully elected assembly in 1975 at a Yellowknife hotel. To meet the demand for government services across the North, the NWT bureaucracy expanded in Yellowknife, bringing in hundreds of families from the south to fill new office towers in the city centre. This steady growth helped stabilize the business community and provided a new focus for entrepreneurial aspirations.

The increased demand for goods and services in Yellowknife also helped to increase the viability of the transportation network, one of the city's most important strengths. The first Yellowknife airport was completed in the 1940s. Today the airport ranks among the top 12 busiest airports in Canada, with 30 commercial jet flights from the south each week and connections to all points in the NWT. The Mackenzie Highway, completed to Yellowknife in the 1960s, provides year-round road access to the city. Trucking firms based in the North took advantage of this new infrastructure and now dominate a busy transport and communications sector.

The late 1970s and early 1980s were characterized by a marked housing shortage, a result of demand created by an expanding government service bureau. The first attempt to meet this need by the private sector resulted in rapid development of apartment and condominium units as well as mobile housing. The shortage of family housing caused considerable social stress. The large number of new and generally young residents and the lack of suitable housing created a high turnover rate and a boom town atmosphere.

A residential construction boom in the late 1980s, combined with the indirect effects of some small-scale, non-renewable resource projects close to the city (Ptarmigan Mine and development of Colomac Mine) and continued government spending, caused the Yellowknife economy to outstrip economic growth in the rest of Canada for the balance of the 1980s.

A business-inspired “buy north” government policy introduced in the late 1980s assisted the development of a wider range of specialized goods and services businesses in Yellowknife, which began to compete with southern suppliers for government capital and operations spending across the North. Engineering services, large project management and contracting firms and related supply businesses brought more new residents to the city. Population growth created a steady demand for residential goods and services, which in turn allowed expansion of the retail and service sectors both in the city centre and closer to the new housing developments.

Yellowknife’s economic growth declined in the early 1990s. This resulted from a national recession, cutbacks in government spending, the absence of a major development project, a long and bitter strike at one of the Yellowknife mines and temporary over-expansion of the city’s housing and retail sectors. Residential and commercial vacancy rates rose, housing prices dropped, stores closed, unemployment rates increased and social services and funding requirements were strained. Yellowknife faced its first real recession in 50 years.

Since 1991, diamond exploration activity has been the principal factor in the recovery of the Yellowknife economy. New mining companies and their suppliers have been added to the business scene. Existing businesses have expanded into mining-related supply activities and have employed more people. The work force has grown, and unemployment has decreased. Mineral-related employment has resulted in more new home buyers entering the market. Slack in the rental market has been taken up by young adults who are now employed and moving out of the family home, and by new residents moving to Yellowknife to provide the necessary skills. Business activity has increased and retail sales have improved. As long as the exploration continues, Yellowknife will maintain slow, but steady growth (Outcrop 1990; Yellowknife 1993, 1994a, personal interviews; Canada, Central Mortgage and Housing 1994a, 1994b).

4.4.1 People/Demographic Profile

Yellowknife is the largest municipality in the NWT, with a population of 17,192 (Yellowknife 1995). The population is estimated to have grown by 2,000 (13%) since the 1991 Census (Table 4.4-1). More than 27% of NWT residents live in the city. When the future Nunavut territory is established in 1999, Yellowknife will have close to half the population of the future Western Arctic territory (NWT Bureau of Statistics 1993).

Table 4.4-1
Yellowknife Population Growth

Year	Population	Percentage Change in Period
1961	3,245	–
1966	3,741	2.9%
1971	6,122	10.4%
1976	8,256	6.2%
1981	9,483	2.8%
1986	11,753	4.4%
1989	13,568	4.9%(1)
1991	15,175	5.9%
1992	15,541	2.4%(2)
1993	16,132	3.8%(2)
1994	16,691	3.5%(2)
1995	17,192	3.0%

Notes:
1: City of Yellowknife Census.
2: Population estimates provided by the Canada Mortgage & Housing Corporation.
Source: Yellowknife 1995 and NWT Bureau of Statistics 1994c.

Table 4.4-2 shows the distribution of the 1991 Yellowknife population by sex and age. Nearly 87% of Yellowknife residents are under 45 years of age, and 45% are between 25 and 44. According to the 1991 census, 49% of those aged 15 years or older have a trade certification, a diploma or a degree (Table 4.4-3).

Table 4.4-2
Yellowknife Population by Sex and Age
1991

	Total	0 to 14 Years	15 to 24 Years	25 to 44 Years	45 to 64 Years	65+ Years
Males	7,885	2,075	1,260	3,465	970	125
Females	7,295	1,910	1,230	3,320	725	105
Total	**15,180**	**3,985**	**2,490**	**6,785**	**1,695**	**225**

Source: Canada Census 1991b.

People of Aboriginal ancestry account for 17% of the city's residents (Table 4.4-4). Residents of N'dilo and Dettah, who have chosen to live on claimed land outside the city, represent 10% of the Yellowknife area Aboriginal population and less than 3% of total city population.

Table 4.4-3
Yellowknife Education Levels
1991

	Total	Males	Females
Population 15 Years & Over	11,140	5,780	5,360
Less than Grade 9	520	270	245
Grade 9 to 13 without Secondary Certificate	2,385	1,255	1,125
Grade 9 to 13 with Secondary Certificate	1,375	605	770
Trades Certificate or Diploma Only	345	255	90
Some University or Non-University without Diploma	1,400	660	740
University or Non-University with Diploma	3,150	1,655	1,490
University Degree	1,965	1,080	890

Source: Canada Census 1991b.

Table 4.4-4
Yellowknife Population by Ethnic Composition
1991

	Population	Percentage
Inuit	310	2%
Dene	1,213	8%
Métis	1,084	7%
Non-aboriginal	12,572	83%
Total	**15,179**	**100%**

Source: Canada Census 1991b.

Yellowknife's population, both Aboriginal and non-aboriginal, is young, mobile, well-educated and culturally diverse. Yellowknife has a very high participation in the labour force (87%) and low unemployment (7%) relative to other NWT communities and the Canadian average (Table 4.4-5) (NWT Bureau of Statistics 1994a).

About a quarter of the adult population is unmarried, and a quarter of the adults were born in the NWT. As of 1991, a third of the population had moved to Yellowknife within the preceding five years. Yellowknife is a multilingual community whose residents have as a mother tongue one of the nine official languages of the NWT or one of a selection of European, Middle Eastern, African and Asian languages (NWT Bureau of Statistics 1995c).

Table 4.4-5
Yellowknife Labour Force
1994

	15 Years and Over	In Labour Force	Participation Rate	Employed	Unemployed	Unemployed Rate
Non-aboriginal	10,701	9,551	89%	9,044	507	5%
Aboriginal*	1,818	1,397	76%	1,157	240	17%
Total	**12,519**	**10,948**	**87%**	**10,201**	**747**	**7%**

Source: NWT Bureau of Statistics 1994a.
* Includes N'dilo.

Since 1991, the total Yellowknife labour force has grown by almost 1,400 people, and 1,000 new jobs have been created. By the year 2000, another 2,000 Yellowknife residents will have reached labour force age. Unemployment peaked in 1992 and has declined since then. Yellowknife unemployment was 747 persons, or 7%, in early 1994. By autumn 1994, unemployment had declined to 500, or just under 5%, largely due to the impact of diamond exploration activity (NWT Economic Development 1994; NWT Bureau of Statistics 1994a).

4.4.1.1 Employment

Of the 10,201 jobs in Yellowknife in 1994, close to 60% were in offices or in health and education. Sales and service occupations provided 19% of employment, and trades and skilled jobs 16%. A total of 72% of the jobs require a trade, a skill or advanced education (NWT Bureau of Statistics 1994a, 1995d) (Table 4.4-6).

Table 4.4-6
Employment by National Occupation Classification
Yellowknife 1994

	Number	Percentage
Management, Skilled Office, Clerical	3,529	35%
Sciences, Health, Education, Government	2,465	24%
Arts, Culture, Recreation, Sport	444	14%
Sales and Service	1,976	19%
Trades, Skilled, Semi-skilled	1,624	16%
Processing, Manufacturing	100	1%
Unaccounted	63	1%
Total	**10,201**	**100%**

Source: NWT Bureau of Statistics 1995d.

4.4.2 Economic Activity/Sectors

NWT economic activity can be divided into six sectors, as categorized by Statistics Canada and the NWT Bureau of Statistics. The following discussion of Yellowknife's economic activity is summarized by these sectors:

- Public Administration/Health/Education (or Government)
- Retail/Accommodation/Food Service
- Transportation/Communications/Construction
- Mining/Manufacturing
- Finance/Other Business/Personal Services
- Renewable Resources.

4.4.2.1 Public Administration/Education/Health

In Yellowknife, federal, territorial and municipal government and health and education agencies account for 43% of the local labour force, or more than 4,000 jobs, spanning several of the categories in Table 4.4-6 (NWT Bureau of Statistics 1995d). This is by far the largest sector of Yellowknife's economy and provides an estimated 48% of personal income. Government is not expected to expand in Yellowknife in the next few years due to the upcoming division of the Northwest Territories and devolution of government to other communities. However, it is not expected to decline in importance to the city.

NWT Government activities based in Yellowknife include support for the NWT Legislative Assembly as well as territory wide planning activities. These include Aboriginal affairs, financial services, computer information services, staff planning, purchasing, project planning, economic planning, educational planning, legal and justice services, health and social services, municipal and community planning, housing, safety and workers' compensation.

The federal presence includes branch offices of Canada Customs, Canada Employment, Canada Mortgage and Housing, Environment Canada, Fisheries and Oceans, Heritage Canada (Parks), Indian and Northern Affairs, Justice, National Defense, Natural Resources, RCMP, Revenue Canada and Transport Canada.

The City of Yellowknife administers fire and ambulance services, municipal finance, local planning and lands, recreation services, bylaw enforcement, roads, water, sewer and garbage. These municipal services are provided by 169 full and part time employees (Yellowknife 1994a and pers. comm.).

Education and health services are included in this public administration sector. Education includes teachers at nine Yellowknife schools, plus Arctic College staff and administration. Health workers include the staff of Stanton Yellowknife Hospital, as well as staff at local medical and dental clinics and workers in the social service field.

4.4.2.2 Retail/Accommodation/Food Service

The retail and accommodation sector includes both retail stores and wholesale suppliers, as well as restaurants and hotels. In Yellowknife, this sector employs 1,115 people, or 22% of the labour force (Table 4.4-7). The sector is dependent for its income on government and other business activity, as well as tourism, and is often the first to be affected in any upturn or downturn in the economy.

Table 4.4-7
Yellowknife Labour Force by Occupation/Income

	Number	Income
Public Administration/Education and Health	43%	48%
Retail/Accommodation/Food Services/Tourism	22%	16%
Transportation/Communication/Construction	15%	15%
Mining/Manufacturing	10%	13%
Finance/Other Business & Personal Services	9%	7%
Renewable Resources	–	–

Source: Canada Census 1991b, NWT Bureau of Statistics 1994c.

Accommodation consists of seven hotels and motels and seven bed-and-breakfast operations, which provide a total of 411 rooms. There are more than 40 fast food outlets, restaurants and licensed bars.

Yellowknife provides goods and services to adjacent communities as well as those located as far away as Inuvik, Cambridge Bay and Rankin Inlet. Northern residents from many other locations now also shop by person or by mail in Yellowknife. Until recently, the limited selection of consumer goods led many northern consumers to shop outside the NWT.

In the past few years, national retail chains have opened stores in Yellowknife to compete with local northern business. The result has been increased selection and on some consumer items, lower prices. The increased supply of goods and services was not accompanied immediately by a similar increase in demand. Therefore, some businesses were forced for a time to reduce staff and/or operations.

4.4.2.3 Tourism

Visitors help support employment in hotels, restaurants, stores and a number of other service businesses. While the volume of visitors to Yellowknife is not large by southern standards, the total number of pleasure travel visitors in any year (20,000) exceeds Yellowknife's actual population. These pleasure visitors create 750 person years of employment in Yellowknife and revenues estimated at $20 million (NWT Economic Development and Tourism 1995d). With its well-developed transportation links and its range of hotel and restaurant services, Yellowknife attracts the spending of both pleasure visitors and Northerners on combined business/leisure trips.

Within an hour by air from Yellowknife there are 16 seasonal lodges and camps catering to anglers and wildlife enthusiasts. Yellowknife is only one hour by air from the barren grounds, where eight licensed outfitters conduct hunting expeditions in autumn.

4.4.2.4 Transportation/Communications/Construction

Transportation/communications/construction represents 15% of Yellowknife's employment base. Transportation by air, road and water is a key component of the Northern economy. Over 20 trucking firms and 13 airlines with bases in Yellowknife move cargo and passengers in, out of and around the city (Yellowknife 1994b). Combined with employment in communications (radio, television, cable TV, telephone, electrical utilities), the transportation sector employs 791 Yellowknife residents (NWT Economic Development and Tourism 1994).

The construction industry depends on demand for new facilities, such as housing, offices, stores and mining development. In 1991, 672 people were employed in construction. This includes qualified tradespeople as well as labourers.

The transportation and construction sector has already responded to the recent discovery of diamonds with increased activity, investment and employment.

4.4.2.5 Mining/Manufacturing

Mining and manufacturing of goods account for 10% of the jobs in Yellowknife, down from 20% in 1971. The Giant and Con gold mines employ the majority of workers in this sector, approximately 660 persons. Employment at these two mines may have reached a peak and appears to be declining (Canada Mortgage and Housing Corporation 1994a). The Giant and Con mines together pay $1.2 million, or almost 10%, of the city's direct tax revenues (Yellowknife 1994a). They have a combined payroll of more than $50 million per year. Statistics on direct employment in exploration activity are not part of this "goods producing" sector, and do not show up in 1991 Census statistics.

Manufacturing is limited in Yellowknife. Publishers, arts and crafts producers and manufacturers of specialized products generate goods primarily for the NWT market.

4.4.2.6 Finance/Other Business/Personal Services

The main businesses in this sector include banks, insurance and real estate businesses, legal firms and accountants. Five chartered Canadian banks provide cash and credit facilities in Yellowknife and to communities outside the city. The Federal Business Development Bank and the NWT Business Credit Corporation also provide financial services to business across the NWT. Computer and advertising services, architects and engineers, management consulting, security and office services all operate in Yellowknife. Personal service businesses include barbers, beauty shops, laundries and dry cleaners. Together these businesses employ 900 city residents, about 9% of the work force.

4.4.2.7 Renewable Resources

The traditional land-based economy, prevalent in the smaller Dene communities in the region, plays a small role in the Yellowknife economy. The wage economy sustains the majority of Yellowknife residents. However, the harvest of renewable resources, a component of the traditional economy, generates income for a small number of Yellowknife residents. Some residents also hunt and fish for food, as do many residents in the smaller communities.

Statistics on hunting and trapping for Yellowknife are unreliable because caribou taken for food by Aboriginal residents are not uniformly reported. Estimates are often combined with those of the smaller communities nearby. However, some indication of the level of activity can be obtained by reviewing hunting statistics. Of the estimated 3,000 Aboriginal residents in Yellowknife, some 600 would hold General Hunting Licences (GHL) as lifelong residents of the NWT (NWT Renewable Resources pers. comm. 1995b). The caribou quota for this group is 1,400. Another 1,300 Yellowknife residents hold sport hunting licences. Sport hunting statistics added to the GHL quota suggest some 3,300 caribou were taken for food in 1992/1993 (NWT Renewable Resources 1994b).

The Bathurst caribou herd ranges very close to Yellowknife in winter, and is accessible by winter road. It is likely that more caribou are being harvested than are counted. A tour of Yellowknife in winter, when carcasses can be seen, indicates that hunting for food still plays quite a large part in the lifestyle of many Yellowknife families.

Income for commercial fishermen based in Yellowknife appears to be decreasing based on Fisheries and Oceans statistics. The six licence holders are estimated to have sold approximately $800,000 worth of whitefish, trout and other Great Slave Lake fish in 1993/1994, down from approximately $1 million in 1992/1993

(Fisheries and Oceans Canada 1994). The average sale per licence in 1993/1994 was estimated at $133,333. Fishing for home consumption also plays a part in Yellowknife lifestyles.

4.4.3 Income and Investment

4.4.3.1 Wages/Employment

Yellowknife residents earn approximately 43% of the personal income reported by NWT residents to Revenue Canada (NWT Bureau of Statistics 1994c), or a total of some $408 million annually. One-third of NWT jobs are located in the capital city.

The average household income for Yellowknife was estimated at $53,000 in 1991 (CMHC 1994a). However, over half of Yellowknife households were estimated to have incomes greater than $76,000 (Canada Census 1991b). The city claim of 14,000 registered vehicles in 1995 is one indication of the high disposable income earned by residents (Yellowknife 1994a).

Approximately 13% of Yellowknife households had a total household income below $30,000 in 1991. Adequate housing for a family is effectively out of reach for this group, who likely depend on social housing supply and/or income supplements.

The economic profile of Yellowknife's Aboriginal community is positive, but not quite as good as that of the city population overall. In 1991, Aboriginal participation in the labour force was estimated at 77% (above the national average of 64%) but with 17% unemployment (the same average as the NWT overall).

4.4.3.2 Other Income

Yellowknife residents earn additional income from investments and transfer payments. In addition to wage income earners, an estimated 300 Yellowknife investors reported $8 million in taxable income in 1991 (NWT Bureau of Statistics 1994c).

Social assistance paid to Yellowknife residents reached an all-time high of $2.25 million in 1993/1994 (Table 4.4-8), up from $1.6 million in 1992/1993. Of the 1993/1994 total, $995,000 is directly attributable to lack of work and income subsidies (Table 4.4-9). Sixty-two percent was paid to residents aged 18 to 34 (Table 4.4-10).

Table 4.4-8
Yellowknife Social Assistance By Year
1990 to 1994

	Dollar Value ($)	Recipients
1993/1994	2,248,078	686
1992/1993	1,650,292	686
1991/1992	1,898,537	941
1990/1991	2,180,484	635

Source: NWT Economic Development and Tourism 1994; NWT Health & Social Services 1995a.

Table 4.4-9
Yellowknife Social Assistance Due to Lack of Employment
1993 to 1994

	Dollar Value ($)	Percentage
Income Subsidy	415,489	42%
No Jobs	106,760	11%
Not Working	464,221	46%
Self-employed	9,050	1%
Total	**995,520**	

Source: NWT Health & Social Services 1995a.

Table 4.4-10
Yellowknife Social Assistance by Age
1993 to 1994

Age	$
0 to 17	$43,449
18 to 24	690,793
25 to 34	719,867
35 to 44	440,688
45 to 59	325,660
60 to 64	106,251
65+	23,354
Total	**$2,250,062**

Source: NWT Health & Social Services 1995a.

In January 1994, of 2,160 persons receiving unemployment insurance benefits in the Northwest Territories (NWT Bureau of Statistics 1994b), more than 700 claims, or 33%, could be attributed to the North Slave region, which includes Yellowknife and the smaller, more traditional Dogrib communities. Yellowknife claimants are estimated to have received $10.7 million in 1994.

4.4.3.3 Cost of Living

Yellowknife's cost of living was estimated to be 30% to 35% higher than Edmonton's in 1991 (NWT Bureau of Statistics 1995c). This higher cost has been attributed to distance from suppliers, cost of transportation, limited volume and limited competition. The difference between Yellowknife and Edmonton may have declined since 1991 due to increased competition in the Yellowknife market. The NWT/provincial differential is eased somewhat by the lack of a retail sales tax in the North.

4.4.4 Infrastructure

The key components of infrastructure are physical facilities and social services. Yellowknife, with good representation in most economic sectors, has a mature economy that supports both physical and social infrastructure.

4.4.4.1 Transportation

The Mackenzie Highway (No. 1 and No. 3), which extends 609 km north from the NWT/Alberta border, and the connecting Liard Highway from British Columbia are part of an essential transportation network linking Yellowknife to other NWT communities and the south. The highway, which includes ferry service across the Mackenzie River, carries a major portion of the freight and fuel bound for Yellowknife. Approximately half the fuel transported is required for Northern mines (McNeill 1995).

The two-lane, all-weather Mackenzie Highway is being widened and paved. Paving will be completed as far as Rae-Edzo by 1996, but plans are not complete for reconstruction of the section from Rae to Yellowknife. Road traffic in the peak summer season was estimated at 500 vehicles a day in 1993 (NWT Transportation 1995). Winter season traffic is estimated at 300 vehicles a day, including considerable local traffic between Yellowknife and Rae-Edzo.

The City of Yellowknife maintains over 50 km of paved streets and has an ongoing paving program designed to provide service to new subdivisions as required. In the 1980s, arterial roads were developed to carry traffic past residential neighbourhoods. Ongoing maintenance and occasional reconstruction are required due to the effects of permafrost underlying much of the city's area (Yellowknife 1994a).

Yellowknife's airport is one of the largest and best served in the North. It is also one of the busiest airports in Canada, with an estimated 60,000 take-offs and landings in 1993 (Canada, Mortgage and Housing 1994a). Air traffic volume has increased by 60% since 1990. NWT Air and Canadian Airlines International's Canadian North service offer up to six daily non-stop jet flights to Yellowknife from Edmonton, Alberta. Jets also connect Yellowknife to Winnipeg. From Yellowknife, airlines carry freight and passengers to all points in the Northwest Territories. The 2,286 m long runways are also used by a Forward Operating Location military base. While busy at certain times of the day, the airport has considerable unused capacity.

4.4.4.2 Municipal Government

Yellowknife is the only city in the Northwest Territories. Its taxable assessments have risen from an estimated $200 million in 1967 to $1,199 million in 1994. The mayor and eight aldermen administer the city's budget and can borrow up to 20% of Yellowknife's taxable assessment. The 1995 operating budget is $27.7 million. Another $14 million has been dedicated for development of the Niven Lake residential subdivision (Yellowknife 1994a).

4.4.4.3 Water/Sewer/Power

Most of the city, and all new subdivisions, are served by piped water and sewer systems. The cost of developing and maintaining this service in rock and permafrost-rich soil accounts for 22% of the municipal budget in 1995. Water is supplied from the Yellowknife River, and is chlorinated and fluoridated. Water treatment facilities consist of a series of settling ponds, which drain into Great Slave Lake. These sewage ponds were recently upgraded and are expected to meet the needs of Yellowknife well into the next century. Work continues on replacement of water and sewer mains in the city centre that have reached the end of their useful life.

A new garbage sorting and compaction facility has replaced the municipal dump, which reached capacity in the early 1990s. The city is currently levying both water and garbage surcharges on municipal water bills to help pay for the new facilities.

The NWT Power Corporation, with an installed diesel capacity of 33.3 MW and a hydro capacity of 25.5 MW, generates electricity for Yellowknife. Hydro-power is shared with the surrounding Dene communities. Expansion of Snare Hydro facilities will add 4.3 MW by July 1996 (NWT Power Corporation 1995a). Electricity is distributed by Northland Utilities.

4.4.4.4 Communications

Yellowknife has a well-established communications network. NorthwesTel provides satellite assisted telecommunications services and has close to 14,000 accounts in Yellowknife, N'dilo and Dettah. Other communications installations include Cable TV receiving and transmission. CBC Television and Television Northern Canada (TVNC) provide network uplink facilities as well as local distribution. CBC AM and FM radio are provided, and there is one private AM radio station and one Aboriginal operated FM radio station. CBC AM radio, the private FM radio and both television networks broadcast in Aboriginal languages as well as English. French language radio and television service is also available. The city is also served by a territorial and a local newspaper.

4.4.4.5 Housing/Home Ownership

Yellowknife has more than 5,600 households (Table 4.4-11) (Yellowknife 1994a). In 1991 home ownership was 42% (Canada Census 1991b), which is estimated to have increased since then. The average cost of a new house in 1995 was $\$80/ft^2$, or \$96,000 for a 1,200 ft^2 home. Added to that would be the cost of the lot, now ranging from \$40,000 to \$80,000.

Table 4.4-11
Yellowknife Housing Stock

Period of Construction	Number of Homes
Before 1946	95
1946 to 1960	280
1961 to 1970	745
1971 to 1980	1,795*
1981 to 1985	625
1986 to 1991	1,400
1992 to 1995 (estimate)	677
Total	**5,617**

* Move of NWT government to Yellowknife.
Note: Homes include detached, semi-detached, row houses, apartments and mobile homes.
Source: Canada Census 1991b, Yellowknife 1994a.

Housing stock includes an estimated 2,843 single family dwellings, approximately 2,500 apartments or rowhouses and over 300 mobile homes. Total vacant houses in November 1994 was estimated at approximately 70 units, most owned by the GNWT and offered for sale. The rental market vacancy rate is expected to be 1% to 2% in 1995 (Canada, Mortgage and Housing 1994a, 1994b).

The City of Yellowknife develops new lots and provides services, while residential developers build the housing. The stock of available stick-built housing lots was reduced to 34 plus 112 trailer lots by March 1995 (Yellowknife Real Estate Board

1995). Ten multi-family building lots and 15 residential/commercial lots were available in spring 1995.

Additional housing needs will be met by the remaining available lots in Range Lake subdivision as well as a new subdivision, Niven Lake, designed to accommodate up to 400 families (Yellowknife 1994d).

4.4.4.6 Recreation

Public recreation facilities include two arenas, a swimming pool, ball parks, recreation parks and walking trails. A 9.6 km walking trail system within the city limits joins residential areas to the city core. School gyms are used by local sports clubs. The ski club operates a series of groomed and lighted cross country ski trails. Yellowknife also has a 9-hole golf course and a 350-seat performing arts centre.

With the exception of the pool and the library, developed recreation facilities are nearing capacity and will need to be supplemented as the population grows. Some open spaces now used for recreation, as well as the ski club area, have been set aside for residential development, which will increase demand on remaining resources, even at normal growth levels. Private recreation facilities include a racquet club and several health clubs (Yellowknife 1994e).

4.4.4.7 Education Facilities

In autumn 1994, the primary and secondary school population was 3,650, with an estimated 1,200 young adults also attending courses at Arctic College (full time and part time). A total of nine schools plus Arctic College facilities accommodate the students. One new school opened in Range Lake in 1994, and a replacement high school is scheduled to open in fall 1995. Two school boards, public and separate, are supported by municipal taxes and government grants. The new high school cost some $10.6 million in NWT government capital costs (Yellowknife Education District No. 1 1994; NWT Financial Management Board Secretariat 1994; NWT Education, Culture and Employment 1995; Yellowknife Catholic Board of Education 1995, pers. comm.).

4.4.4.8 Health Facilities

Yellowknife is home to Stanton Yellowknife Hospital, a 135-bed regional hospital, completed in 1988. It is the largest hospital in the North and currently operates 100 beds at 62% of capacity. Approximately 58% of users are from surrounding communities. The hospital has 19 specialists on staff and receives visiting specialists on a scheduled basis. Hospital services are assisted by a variety of social agencies and community groups trained and able to respond to special needs. Yellowknife facilities also include a Public Health Unit, the Stanton Eye

Team (which serves the whole Arctic) and several independent medical clinics and dental clinics (Stanton Yellowknife Hospital 1995).

4.4.4.9 Social Facilities

Social facilities consist of government agencies, care giving organizations and protection services.

The GNWT provides a number of programs to Yellowknife residents through a district social services office. Coordination between various care giving organizations, from government services to health and social service and religious organizations, Canada Employment and police, has become a priority for the government. Yellowknife has some experience with this group approach as a result of the effects of the Giant Mine strike. Services noted here are often interdependent and linked by referrals.

Some social services agencies include group homes for children and adults, shelters for battered women and children and a detox centre and treatment centre operated by Northern Addiction Services. Social service organizations include such groups as Scouts and Guides, Block Parents, a help line, the Council for the Disabled and the Association for Community Living (NWT Health and Social Services 1995c).

A number of churches serve those who worship in Yellowknife. Churches represent the following denominations: Anglican, Bahai, Baptist, Calvary Community, Church of Christ, Latter Day Saints, Nazarene, Seventh Day Adventist, Pentecostal, Lutheran, Jehovah Witness, Roman Catholic and United.

4.4.4.10 Protection Services

Yellowknife is the headquarters for the "G" Division of the RCMP, responsible for policing in the NWT. In addition, the RCMP has a Yellowknife detachment of some 28 officers. RCMP statistics indicate that criminal code and traffic offences declined in 1994 from 1993. However, drug charges, a growing Northern concern, increased more than 9% in 1994 over 1993. Liquor offences cleared by charge increased by 2%, roughly equivalent to the estimated population increase. Liquor offences represent 39% of the cases handled by the Yellowknife detachment. Traffic offences cleared by charge declined 60% in the same period (RCMP "G" Division 1995b).

Figure 4.4-1 provides a comparison of the incidence of community violence and abuse, based on RCMP cases for 1994 in Yellowknife and three Alberta communities with similar attributes. Population figures are approximate.

The high incidence of alcohol and drug cases per 100 population over the age of 15 compared to Alberta communities can be clearly seen. Yellowknife RCMP cases related to alcohol abuse occur at three times the Alberta rate. The incidence of drug cases is also higher in Yellowknife than in similar communities in Alberta.

Assault cases (which may be related to alcohol abuse) are more frequent in Yellowknife than in comparable Alberta communities.

Property damage rates, largely break and enter and petty theft, are somewhat more severe in Yellowknife than in comparable Alberta communities.

City of Yellowknife protection services include bylaw and fire and ambulance service. The City of Yellowknife bylaw detachment, with a staff of 11 officers, provides traffic control and enforcement of other municipal bylaws. The municipal fire department, with a full time staff of 19, also operates the ambulance service, with a staff of four. This service also includes many trained volunteers (Yellowknife 1995a).

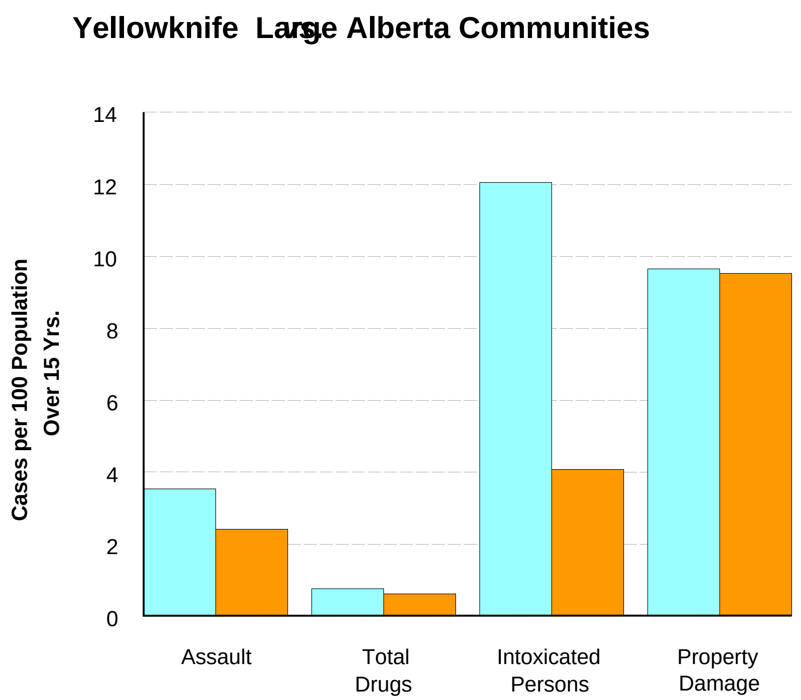
The Yellowknife Correctional Centre is one of several GNWT facilities across the North.

4.4.4.11 Commercial/Industrial

In the 1980s, a 150 ha industrial park was opened at one end of the city. Another 150 ha is available for future expansion. Both the industrial park and extensive areas of the downtown and commercial service zones are under-utilized and could be redeveloped (Yellowknife 1994f).

4.4.4.12 Financial Resources

Yellowknife residents and businesses, through direct taxes, user fees and purchase of developed land, account for approximately $24 million, or well over 80% of the City's 1995 $27 million budget. Residential and multi-residential property owners paid approximately $5 million in taxes on a total land and housing assessment of $666 million (Table 4.4-12). Commercial and industrial land and buildings, mines and high density parking have a total assessed value of $533 million, for total tax revenues of $7.5 million (Yellowknife 1995b).



Yellowknife

Population over 15: 12,519

Large Alberta Communities (Fort McMurray, Grand Prairie, Peace River)

Population over 15: 17,660

NOTE: **Based on estimated population over 15 years of age, 1994.**

May not fairly represent community violence cases over a period of time.

NWT DIAMONDS PROJECT

Figure 4.4-1
RCMP Statistics for 1994—
Yellowknife/Large AB Comm.

Source: RCMP Statistics for 1994

Table 4.4-12
Yellowknife Tax Assessments/Revenues
1994

Class	Assessment ($)	Revenue ($)
Residential	512,976,800	3,798,579
Multi Residential	153,415,600	1,242,597
Commercial & Industrial	439,475,000	6,250,675
Mining & Quarrying	90,551,600	1,235,804
High Density Parking	3,212,500	43,372
Total	**1,199,631,500**	**12,571,027**

Note: Federal and Territorial Governments pay contributions in-lieu-of-taxes on their city properties.
Source: Yellowknife 1994f.

Government grants-in-lieu-of-taxes, and support for such community activities as ambulance service and certain recreation activities, is estimated at $2.3 million. In addition, under a block funding arrangement, the GNWT provides $4.1 million annually to the municipality. The government contribution amounts to approximately 20% of the municipality's total revenue (Yellowknife 1994a).

4.4.5 Capacity for Growth

Yellowknife's planning department is responsible for assessing population needs and establishing infrastructure replacement requirements. The city has a general plan and regularly updates this information. The city has a list of alternative development sites and preliminary costings on which to base future decisions. Depending on the rate of population expansion, the city has plans to meet three to ten years' housing demand (Yellowknife 1994g).

Community facilities are not fully utilized and show some capacity for absorbing limited population increases. Tables 4.4-13 to 4.4-16 list community facilities and indicate the level of current usage.

4.4.5.1 Work Force

Based on current school populations, the work force age population is predicted to grow by some 2,000 current students by the year 2000. This increase cannot be absorbed through departures from the work force by age or death, as the work force is on average far from retirement age. Capacity of business and government to employ these students is dependent on economic growth. In the past the economy has absorbed these new workers. Yellowknife businesses also import

Table 4.4-13
Yellowknife Municipal Facilities/Capacity

	Capacity	% Usage	Projected New
Stanton Yellowknife Hospital	100 beds	62%	Capacity of hospital is 135 beds
Schools			
Mildred Hall	550	76% (422)	
Ecole A. St-Cyr	88	52% (46)	
J.H. Sissons	418	84% (351)	
N.J. MacPherson	374	78% (292)	
William McDonald	472	74% (347)	
Range Lake North	440	64% (283)	
Sir John Franklin	778	82% (635)	
St. Patrick's High	400	85% (338)	September, 1995
St. Patrick's Elementary	330	86% (282)	
St. Joseph's	495	94% (536)	
	4,345	81% (3,532)	Capacity for 800+ students
Community Services			
Yellowknife Community Arena	612	95%	2010 - 2014 (projected new)
Gerry Murphy Arena	300	95 to 100%	Immediate requirement
Ruth Inch Pool	275	-	Population 30,000
Curling Club	202 (8 sheets)	-	
Public Library	80	Based on circulation	Population 30,000

Source: Yellowknife 1994e; Yellowknife Education District No. 1 1994; Yellowknife Catholic Board of Education 1995.

Table 4.4-14
Yellowknife Municipal Facilities/Capacity

Public Safety		Manpower	Notes
Firefighting		19 full time	
		20 volunteer	Requirement measured in response time
Ambulance		4 full time	
		30 standby	
		3 vehicles	
Police	- RCMP	30 full time	
	- Bylaw	11 full time	

Source: Yellowknife 1995a.

Table 4.4-15
Yellowknife Municipal Facilities/Capacity

	Average Hours Available per Week	Percent Usage (h/wk)
Sportsfields		
Sir John Franklin	20	85% (17)
St. Joseph's	20	100% (20)
Parker RF #1	20	88% (17.5)
Parker RF #2	20	100% (20)
Fritz Theil #1	20	100% (20)
Fritz Theil #2	20	100% (20)
William McDonald (Ball)	20	53% (10.5)
William McDonald (Pitch)	20	68% (13.5)
Range Lake North	20	100% (20)
Tommy Forrest	20	100% (20)
Mildred Hall	20	37.5% (7.5)
Sissons	20	37.5% (7.5)
N.J. McPherson	20	37.5% (7.5)

Source: Yellowknife 1995c.

Table 4.4-16
Yellowknife Municipal Facilities/Capacity

Outdoor Facilities*	Usage	Replacement
2 Fastball Parks	95% to 100%	2010 to 2014
5 Softball Parks	95% to 100%	1995 to 1999
1 Full Size/4 Modified Soccer Fields	95% to 100%	Immediate
1 Track & Field Pit	–	–
5 Tennis Courts	95% to 100%	2000 to 2004

* Capacity rates are based on summer months and on weather.
Source: Yellowknife 1995c.

skilled workers to meet needs as they arise. As long as the labour market in southern Canada is weak, there is usually no problem in filling new jobs or replacing workers.

4.4.5.2 Social Leadership Resources

The Yellowknife population includes many educators, health and social services professionals and recreation specialists who contribute time and services to the community. Perhaps as a result, Yellowknife tends to take an organized, group approach to providing care and activities for its citizens. In spite of rapid expansion and urbanization, the city retains a large and active volunteer sector, which cooperates with social agencies in times of need.

The broad experience of the adult population ensures there is an adequate supply of people to take on leadership positions; the number of people eager to run in recent municipal elections confirms their willingness to do so.

4.4.6 Outlook

4.4.6.1 Community Attitudes

Community attitudes to continued growth in Yellowknife are mixed. As the influence of government declines, there is concern for the future of Yellowknife in some quarters. The city is too far from the southern marketplace to participate in more diversified industrial development. It is reliant on non-renewable resources. Its history is characterized by rapid growth based on government and development of non-renewable resources. Yellowknife's future is tied to development of the North.

In response to the recession of the early 1990s, Yellowknife's City Council declared the city "Open for Business" and stepped up a campaign to encourage environmentally responsible non-renewable resource development anywhere in its trading area. The excitement and activity surrounding the discovery of diamonds in the NWT has encouraged a positive attitude to mining and mineral development among many sectors of the city's population.

4.4.6.2 Potential to Benefit from the NWT Diamonds Project

Of the 1,500 licensed businesses based in the city, some 225 Northern resident businesses can provide services to the mining industry. These include over 100 businesses in construction and other trades, 20 involved in road transport and 13 involved in air transport. An estimated 33 of these Northern resident businesses provide professional services such as engineering and project management (Yellowknife 1994b).

In addition, wholesale and retail businesses have responded to the requirements of the exploration industry and future mine requirements by adding product lines and negotiating agreements to represent mining industry suppliers.

4.5 Hay River

Hay River is a key transportation centre on the south shore of Great Slave Lake, 494 km by road from Yellowknife and 1,067 km north of Edmonton, Alberta.

Hay River is located at the intersection of highways linking southern NWT communities. The community is also the terminus of the Canadian National (CN) northern rail line from Edmonton, which is the only rail line in the NWT. As well, it is the departure point for marine barge service to Yellowknife, Mackenzie River communities and the Arctic Coast.

The mouth of the Hay River was a stop-over point for the Slavey people for many hundreds of years. The location first appeared on maps in 1854. By the 1860s, a group of Slavey had settled there, and the Hudson's Bay Company and the Roman Catholic Church established posts.

In 1900, the Hay River Dene asked to be included under Treaty 8. The RCMP opened a post in 1925, joining the Anglican mission at the small Dene community on the east bank of the river.

In 1939, a trail was opened from Grimshaw, Alberta, to Hay River to assist in supplying the gold mines at Yellowknife. The first shipping companies hauled freight over Great Slave Lake to Yellowknife by cat train – huge sleds hauled by tractors. A productive commercial fishery was soon established on Great Slave Lake, which continues to this day.

In 1942, the U.S. Army Corps of Engineers built an airstrip on Vale Island at the river's mouth to serve the Canol Oil Pipeline Project at Norman Wells. The RCMP opened a permanent post in the new and expanding community in 1947, and in 1948, the Mackenzie Highway was opened. The new road link completely replaced the Slave River route, the traditional water and land route to the north, and Hay River became the centre of a new transportation industry.

A shipyard was developed to build and service the Mackenzie River tug and barge fleet, which supplied the growing communities on Great Slave Lake, the Mackenzie River and the western Arctic coast. By 1963, the community had achieved town status. In 1964, the Great Slave Lake Railway, a CNR rail link to Roma, Alberta, was completed as part of a development package to serve Cominco's Pine Point lead zinc mine east of the town.

The railway spur added tremendous freight handling capacity to the community. When major resource companies began exploring the Mackenzie Delta and Beaufort Sea for oil and gas in the late 1960s and early 1970s, Hay River capitalized on the opportunity. Transshipment facilities were expanded and upgraded and for a time the town bustled with activity. Although oil and gas activity declined after 1975, Hay River continued to supply goods and services to Pine Point mine for another 12 years until 1988 when the mine was permanently shut down.

In 1974, Hay River Dene, concerned about the development of the town and potential mine expansion, negotiated reserve status for their long established east bank community. The area, some 1,800 ha, was the first reserve in the NWT and to some extent serves as a model for negotiation of the current claims under Treaty 8.

The completion of the Dempster Highway through the Yukon to Inuvik in 1979 diverted some freight bound for the Mackenzie Delta, and Hay River's key role in transportation and development of the Mackenzie Valley and Beaufort Sea began to decline. The town and its businesses hung on through the 1980s by continuing to supply Pine Point Mine. Hopes of growth based on new gold mining projects were dashed as the mines passed the community by. At one point, it appeared even the rail link would be shut down. Gradually, however, the business community turned its expertise in transportation to trucking. Business also diversified into two new sectors, agriculture and manufacturing (Outcrop 1990 and pers. comm.).

Market gardens had helped to sustain the first missionaries in the area, and as the highway stretched north from Grimshaw to Hay River, farmers followed. Prevented from expansion by government reserves for future land claims, the agricultural sector near Hay River concentrated on productivity. In the 1980s, garden farms were joined by poultry operations, raising chickens and producing eggs for the Northern market.

The relatively fertile soils and long summers of the area provided another resource for Hay River businesses. Small-scale logging operations offered a ready source of rough timber. Manufacturing businesses based on wood products were started in the early 1990s. The fledgling industry, which manufactures furniture and other items, is a symbol of the tenacity of the Hay River business community.

Trucking, and to some extent, air transport, are more closely allied to Hay River's traditional role as the transportation hub of the Western Arctic.

Today, Hay River has a diverse and experienced small business community with initiative and small business management expertise. The community's development has long been dependent on major non-renewable resource projects, and its prosperity in the past has been tied to the boom and bust spin-off effects of major development (Fresci 1995).

4.5.1 People/Demographic Profile

Hay River is the fourth largest community in the NWT, with a 1995 population of 3,400 (Table 4.5-1) (Hay River 1995a). The Hay River Reserve had a population of some 216 persons in 1991 (Canada Census 1991b). The two communities combined represent approximately 5% of NWT population and 8% of western Arctic population.

Table 4.5-1
Hay River Population Growth

Year	Population
1981	2,863
1986	2,964
1991	3,206
1995	3,400

Source: Canada Census 1991b; Hay River 1995b.

Aboriginal residents make up approximately a third of the Town of Hay River's population (Table 4.5-2). The 1991 census indicated most residents speak English as a mother tongue; however, Aboriginal groups represented include Cree, Slavey, Chipewyan and a large Metis population.

Table 4.5-2
Hay River Ethnic Composition
1991

	Population
Inuit	30
Dene	308
Metis	667
Non-aboriginal	2,201
Total	**3,206**

Source: NWT Bureau of Statistics 1995c.

In 1991, more than 40% of the population was under 25 years of age (Table 4.5-3), and more than a third, or 1,210, were in the 25 to 44 age group. According to the 1991 census (Table 4.5-4), 40% of those aged 15 years or older have a trade certification, a diploma or a degree. About 11% have less than a grade 9 education. About 40% of the population was single in 1991, and more than half Hay River's residents were born in the NWT (NWT Bureau of Statistics 1995c).

With an economy based on largely seasonal business, Hay River's labour force (Table 4.5-5) is characterized by a high participation rate (82%) and moderate unemployment (14%) compared to other NWT communities (NWT Bureau of Statistics 1994a). It should be noted that many residents work only part of the year on seasonal activities (Canada Human Resources 1995). Unemployment

Table 4.5-3
Hay River Population by Sex and Age
1991

	Total	0 - 14 Years	15 - 24 Years	25 - 44 Years	45 - 64 Years	65+ Years
Males	1,685	455	255	635	275	50
Females	1,525	415	270	570	225	50
Total	**3,205**	**870**	**520**	**1,210**	**505**	**105**

Note: Numbers may not add due to rounding by Census Canada.
Source: Canada Census 1991b.

Table 4.5-4
Hay River Education Levels
1991

	Total	Males	Females
Population 15 Years & Over	2,310	1,210	1,100
Less than Grade 9	245	135	110
Grade 9 to 13 without Secondary Certificate	650	325	325
Grade 9 to 13 with Secondary Certificate	240	90	145
Trades Certificate or Diploma Only	125	105	20
Some University or Non-University without Diploma	260	105	155
University or Non-University with Diploma	625	355	275
University Degree	165	95	75

Source: Canada Census 1991b.

figures may be misleading. Since 1991, the labour force age population is estimated to have grown by some 250 people. Another 400 children will reach labour force age by the year 2000.

4.5.1.1 Employment

Total employment in Hay River in 1994 was 1,796 (NWT Bureau of Statistics 1994a). Roughly 43% of the jobs were in management or skilled office occupations, science, health, education and government (Table 4.5-6). Some 423 (23%) workers are in trades and manufacturing (the highest percentage in the NWT). Of the jobs in Hay River, 75% require on the job training or other education.

Table 4.5-5
Hay River Labour Force
1994

	15 Years and Over	In Labour Force	Participation Rate	Employed	Unemployed	Unemployment Rate
Non-aboriginal	1,770	1,480	84%	1,307	173	11%
Aboriginal*	801	620	77%	489	131	21%
Total	**2,571**	**2,100**	**82%**	**1,796**	**304**	**14%**
Hay River Reserve Labour Force 1994						
Reserve Population	169	96	57%	61	35	36%

* Aboriginal groups include: Cree, Slavey, Chipewyan and a large Metis population.
Source: NWT Bureau of Statistics 1994a.

Table 4.5-6
Employment by National Occupation Classification Hay River
1994

	Number	Percentage
Management, Skilled Office, Clerical	520	29%
Sciences, Health, Education, Government	260	14%
Arts, Culture, Recreation, Sport	46	3%
Sales and Service	520	29%
Trades, Skilled, Semi-skilled	395	22%
Producing, Manufacturing	28	1%
Unaccounted	27	2%
Total	**1,796**	**100**%

Source: NWT Bureau of Statistics 1995d.

4.5.2 Economic Activity/Sectors

Hay River has some 540 licensed businesses (Hay River 1995b), representing a wider range of sectors than any other community in the Northwest Territories (Table 4.5-7). This is particularly noticeable in the renewable resources sector and in Hay River's relatively successful manufacturing sector.

Table 4.5-7
Hay River Labour Force by Occupation/Income

	Number	**Income**
Public Administration/Education and Health	33%	41%
Retail/Accommodation/Food Services/Tourism	22%	16%
Transportation/Communication/Construction	25%	28%
Mining/Manufacturing	3%	4%
Finance/Other Business & Personal Services	12%	11%
Renewable Resources	5%	N/A
Total	**100%**	

Source: Canada Census 1991b; NWT Bureau of Statistics 1994c.

4.5.2.1 Public Administration/Education/Health

In Hay River, federal, territorial and municipal government and health and education agencies account for some 33% of the labour force, or 630 jobs. This sector has grown in the past few years as a result of relocation of some NWT government agencies to Hay River. The NWT Power Corporation, for example, moved its head office from Edmonton to Hay River in 1989. Northern Transportation Company Ltd. moved its head office to Hay River in 1994.

Other services have been moved to Hay River from Yellowknife as a result of the territorial government decentralization policy. Government offices in Hay River include NWT government highway operations, a territorial correctional centre, territorial forest management, NWT Library Service headquarters, the territorial liquor commission and the NWT Public Utilities Board, as well as a regional social services office. In addition to the RCMP detachment, the federal government maintains a Coast Guard base, a Fisheries and Oceans base and a Canada Employment office. The Freshwater Fish Marketing Corporation processes fish in Hay River for export from the NWT.

Hay River's H.H. Williams Hospital employs five physicians and 15 nurses, and three Hay River schools have a total of 52 teachers. Arctic College also offers training in the community. The town provides recreation, land development, road development and maintenance, water, sewer, and garbage facilities, as well as cable television (Hay River 1995a and 1995b).

4.5.2.2 Retail/Accommodation/Food Service

This sector, which includes retailers as well as hotels and restaurants, is the third largest employer in Hay River (Table 4.5-7), with approximately 22% of the work force, or 425 employees.

Hay River has five hotels and motels with more than 100 rooms. More than a dozen restaurants and licensed bars attract community residents, highway travellers and residents of surrounding communities.

The Town of Hay River estimates its trading area has a population of 8,500, primarily residents of smaller communities located on the NWT highway system. As a result, the retail sector offers a variety of services, including department stores, clothing, furniture and hardware, many of which are located in an assortment of downtown mall developments.

Hay River businesses also serve the mining industry. A variety of goods and services either pass through Hay River or are supplied by Hay River businesses. In 1994/1995, for example, Hay River was the transshipment point for fuel for Colomac Mine. Heavy equipment and many types of parts were supplied to the mine by local dealerships (King 1995). Lupin Mine's requirement for cement was met by Hay River as well. The ingredients were shipped by rail tanker to Hay River, where a bagging operation was set up to prepare the cement for shipment by flatbed truck to Lupin via the highway and winter road.

4.5.2.3 Tourism

Hay River, with its varied service sector, is close to the junction of all southern NWT Highways and attracts many road travellers. The town is within a day's drive of Fort Simpson, gateway to Nahanni National Park, and of Fort Smith, headquarters of Wood Buffalo National Park. A number of seasonal visitor services provide tours on Great Slave Lake as well as fly out fishing. While not a large direct employer in the Hay River economy (Table 4.5-7), tourism indirectly provides considerable employment for Hay River residents.

4.5.2.4 Transportation/Communications/Construction

This sector, the second largest employer after government (Table 4.5-7), still provides the main driving force for the Hay River economy. Of the three subsectors, transportation is the largest, with 210 workers.

In addition to trucking, Hay River businesses offer air services, both scheduled and charter. The community also serves as an air tanker base for summer forest fire fighting. The railway, which hauls heavy equipment and bulk fuel and fertilizer, creates some employment in the community and seasonal marine freight services account for a large number of positions each summer (Vanderploeg 1995).

The construction industry provides site development and winter road and ice bridge construction services, as well as more traditional construction skills. Communications activities in Hay River include telephone, electrical generation and distribution services. The transportation/communications/construction sector represented 25% of Hay River employment, or 465 jobs, in 1991.

4.5.2.5 Mining/Manufacturing

When the Pine Point open pit lead zinc mine was closed, a number of Pine Point residents resettled in Hay River. Today, many of these work for Royal Oak's Colomac mine, northwest of Rae. Hay River serves as a gathering point for rotating mine employees, some of whom live in Alberta. Hay River also benefits from mining through supplying goods and services (Section 4.5.2.2) (Hay River 1995a).

Manufacturing is the fastest growing part of the Hay River economy. Services include meat and poultry, fish products, a sawmill, publishing, metal fabrication and ship repair. In addition, manufacturers of furniture, doors, roof trusses and windows are located in town. The metal fabricators can supply steel storage tanks and tanker trucks, and all types of heavy duty welding.

Many of these businesses, as well as the Colomac mine, have opened or reopened in the past five years, and employment figures would not be reflected in 1991 Census count of 65 persons in mining and manufacturing. In early 1995, employment in this sector is conservatively estimated at double that, or more than 130 persons (Table 4.5-7), about the same number as are employed in construction.

4.5.2.6 Finance/Other Businesses/Personal Services

Hay River has two chartered banks, insurance services, real estate brokers, legal firms and accountants. This sector also includes engineering, management consulting, office services and personal services such as barbers, beauty shops, laundries and dry cleaners. Together these businesses employed 220 people in 1991, or 12% of the labour force.

4.5.2.7 Renewable Resources

Commercial fishing is an important industry to Hay River. A fleet of fishing vessels make their home port in the town. Fisheries and Oceans Canada licenses some 30 operations, with an estimated 110 employees in 1992/1993. The annual quota for whitefish, trout and other Great Slave Lake species, as well as pickerel from nearby lakes, is approximately three million pounds. Total sales in 1992/1993 were estimated at $1.2 million (Canada, Fisheries and Oceans 1994, 1995a).

The fertile soil and warm summers of the south Slave region provide good growing conditions for spruce logs. A sawmill in Hay River processes logs for export.

Hay River agricultural products include vegetables from market gardens along the Hay River, as well as poultry and eggs and pork. The town is working with local business to encourage the establishment of a meat and poultry processing facility, which would also handle processing of wild meat (Hay River 1995a).

4.5.3 Income

4.5.3.1 Wages/Employment

In spite of its small size, Hay River accounted for more than 7% of the total NWT personal income reported to Revenue Canada in 1991. Some 1,700 residents filed taxable returns in 1991, compared to a work force of 1,850 persons. Approximately 90% of Hay River personal income is obtained from employment. Average income for full time workers is estimated to be $40,090, and part time workers, $18,000 (Table 4.5-8) (NWT Bureau of Statistics 1994c).

Table 4.5-8
Hay River Wage Based Income

	Hay River
Full time Employment	960
Full time Average Wage ($)	40,090
Part time Employment	1,005
Part time Average Wage ($)	18,000
Total Estimated Wage ($)	56,576,400
Total Reported Income ($)	69,743,000
Social Assistance 1993/1994 ($)	856,368
Unemployed 1994	304
Unemployment Insurance Estimate 1994 ($)	4,560,000

Source: NWT Health and Social Services 1995a;
Estimates based on NWT Bureau of Statistics 1994c, with some adjustments.

4.5.3.2 Other Income

In addition to wages, Hay River residents declared approximately $100,000 in other income in 1991. Transfer payments accounted for approximately 6% of personal income.

Social assistance in Hay River climbed from $239,000 in 1988/1989 to over $832,000 in 1992/1993 (Table 4.5-9) (IAND 1993). More than 43% of payments in 1993/1994 were directly attributable to lack of work (Table 4.5-10). Payments doubled at the Hay River Reserve in the same period. Even with these large increases in payments, Hay River has one of the lowest levels of per capita assistance in the NWT (Table 4.5-11).

Table 4.5-9
Hay River Social Assistance Changes

	Dollar Value ($)	Recipients
1994/1995	650,476	592
1993/1994	856,311	597
1992/1993	832,648	592

Source: NWT Health and Social Services 1995a.

Table 4.5-10
Hay River Social Assistance Due to Lack of Employment 1993/1994

	Dollar Value ($)	Percentage
Income Subsidy	119,403	32%
No Jobs	132,868	36%
Not Working	118,700	32%
Total	**370,971**	

Source: NWT Health and Social Services 1995a.

Table 4.5-11
Hay River Social Assistance by Age 1993/1994

Age	Dollar Value ($)
0 to 17	3,182
18 to 24	228,399
25 to 34	286,593
35 to 44	123,251
45 to 59	172,699
60 to 64	24,535
65+	17,852
Total	**856,311**

Source: NWT Health and Social Services 1995a.

4.5.3.3 Cost of Living

Hay River's cost of living was estimated to be 35% to 40% higher than Edmonton's in 1991 (NWT Bureau of Statistics 1995c). Costs may be actually in the range of 15% to 20% higher than Edmonton, since food and housing prices are less than Yellowknife. Municipal taxes and power costs are also lower than Yellowknife.

4.5.4 Infrastructure

The key components of infrastructure are physical facilities and social services. Hay River, with representation in most economic sectors, has a mature economy with limited physical and social infrastructure.

4.5.4.1 Transportation

Mackenzie Highway (No. 2) stretches 43 km north from Highway No. 1 and serves as an access road to Hay River. The highway is paved and is maintained by the territorial Department of Transportation. The town has 14.5 km of paved roads and 38 km of gravel roads (Hay River 1994). Traffic on the highway averaged 450 vehicles per day in summer 1993. Winter traffic was estimated at 300 vehicles per day (NWT Transportation 1993). It is not known how much of this traffic can be attributed to local traffic between south Slave region communities.

Hay River is served by the Great Slave Lake railway, a freight service, from Roma, Alberta. Freight and bulk products are off-loaded from rail cars and loaded onto trucks in the 28 ha marshalling yards of Northern Transportation Company Limited at Hay River. Northern Transportation's yards were expanded in the 1970s to meet demand for supplies for Beaufort Sea exploration. Capacity of the rail/truck/barge transfer facility currently exceeds demand. Two trains a week brought fuel in the winter of 1994/1995 to supply Hay River and, by subsequent tanker truck, to Yellowknife and four mining operations (Colomac, Lupin, Giant and Con) (Vanderploeg 1995) plus the NWT Diamonds Project exploration phase. Rail tankers also carried tonnes of bulk cement in late 1994, which was bagged in Hay River for shipment by flatbed truck to Lupin Mine by winter road (Vanderploeg pers. comm. 1995).

Hay River's airport is capable of handling passenger jet traffic, although the runway requires upgrading. The airport handles Canadian Regional connector flights from Edmonton and Fort Smith to Yellowknife and regional airlines connecting Hay River and Yellowknife. The airport has an average of six passenger flights a day.

4.5.4.2 Municipal Government

Hay River's taxable assessment base is approximately $113 million, up $7.27 million since 1992 (Table 4.5-12). Run by an elected mayor and eight aldermen, the town sets its own budget and has the power to borrow. The town's 1995 operating budget is $4.72 million. A total of $733,000 is allotted for additional lot development and servicing. Some capital projects are eligible for GNWT Municipal Capital Assistance funding. This assistance is estimated at approximately $100,000 in 1995 and $500,000 in 1996 (Hay River 1994). In addition, the GNWT Capital Plan calls for expenditures of some $3.6 million in 1995 to 1996 and $1.8 million in 1996 to 1997 (Table 4.5-13) (NWT Financial Management Board Secretariat 1994).

Table 4.5-12
Hay River Tax Assessments
1994

Class	$ Million
Residential	57.8
Commercial	32.6
Industrial	1.9
Transportation	15.3
Other	5.6
Total	**113.1**

Source: Hay River 1995d.

Table 4.5-13
GNWT Capital Plan Hay River,
1995 to 1997

Hay River	1995/1996 ($)	1996/1997 ($)
Water, Sewage, Solid Waste	415,000	406,000
Schools	1,980,000	1,430,000
Roads - Hwy/Municipal	1,025,000	
Renewable Resources/Parks	187,000	
Total	**3,607,000**	**1,836,000**
Hay River Reserve	300,000	

Source: NWT Financial Management Board Secretariat 1994.

4.5.4.3 Water/Sewer/Energy

The new area of the town is served by piped water and sewage service. The older area, now partly industrial, and the land to the south of town are provided with water and sewage services by truck. The town has 1,200 customers on piped service and 200 on truck service.

Water drawn from Great Slave Lake is chlorinated. Fluoridation facilities will be brought into operation in 1995. The town has a primary sewage lagoon. A new site has been selected for a landfill, and development will start in 1995, as the current site is nearing maximum capacity. These services are supplied by the town, at a total budgeted cost in 1995 of $2.1 million. GNWT grants and transfers related to these services amount to $932,000 (Hay River 1994). Power is supplied to Hay River from the Talston Hydro facilities (built to supply Pine Point Mine), with tie line capacity of 10 MW. Peak load in 1995 was 5.8 MW. Full diesel backup of 6.2 MW is available. Power is distributed by Northland Utilities (NWT) Ltd. (Hay River 1995a).

4.5.4.4 Communications

Hay River is served by NorthwesTel, whose satellite assisted service spans the NWT. The town of Hay River provides Cable TV service to all households. Radio service includes CBC and two private stations based in Yellowknife. The community also has a local newspaper.

4.5.4.5 Housing/Home Ownership

Hay River had a housing stock of 1,070 in 1991 (Table 4.5-14). Approximately 55% were owned. The average value of a single family dwelling was $85,000 in 1991 (Canada Census 1991b). Housing stock includes an estimated 900 single family dwellings, 175 apartments and row houses, and approximately 40 other housing units. The vacancy rate for rental accommodation in spring 1995 was 1% (Hay River 1995a).

The town develops new lots and provides services. A total of 83 residential lots were added in 1989, and 20 of these were still available in 1995. Another 65 lots will be developed in 1995, an estimated three-year supply at current population growth. Residential lots range in price from $3,500 without services to $31,500 and up with services (Hay River 1995c).

4.5.4.6 Recreation

Community recreation facilities include an arena, a pool, curling club, ball parks, a tennis court and recreation parks. In total, green space maintained by the town amounts to 16 ha.

Table 4.5-14
Hay River Housing Stock

Period of Construction	Number of Homes
Pre 1946	10
1946 to 1960	80
1961 to 1970	315
1971 to 1980	485
1981 to 1985	90
1986 to 1991	90
1991 to 1995 (estimate)	20
Total	**1,090**

Note: Includes detached, semi-detached, row houses, apartments and mobile homes.
Source: Canada Census 1991b; Hay River 1994.

Approximately 20% of the municipal budget is spent on recreation. The town has a golf and country club and a ski club with 26 km of lighted, groomed trails. The territorial library serves as a community library and receives town funding. Community plans call for replacement of facilities at one ball park and ongoing maintenance and expansion of existing facilities (Hay River 1994).

4.5.4.7 Education Facilities

Schools in Hay River are nearing capacity. The GNWT plans to spend some $3.8 million to renovate the Diamond Jenness High School starting in 1995/1996 (NWT Financial Management Secretariat 1994). Total school population is 960, up from 716 in 1989 (Hay River 1995a). Post-secondary education is available at Arctic College in Fort Smith. Education taxes collected by the town are passed on to the territorial government.

4.5.4.8 Health Facilities

The H.H. Williams Hospital is nationally accredited and operates 50 beds. Physiotherapy, X-ray and lab facilities are provided. Air medivac service to Yellowknife or Edmonton is through St. John Ambulance from Yellowknife.

4.5.4.9 Social Facilities

Social facilities consist of government agencies, care giving organizations and protection services. A full range of community health programs is available, including home care, environmental health and safety, public health, childbirth education and community health education. Three dentists and two chiropractors serve the community, and a pharmacy provides prescription service. A seniors lodge and extended care facility help to meet the needs of a relatively large number of people over the age of 65. A safe home network provides shelter for women, and a group home is provided to assist children in need (Hay River 1995b; NWT Health and Social Services 1995b).

A number of churches serve the community of Hay River. Churches represent the following denominations: Roman Catholic, Anglican, United, Jehovah Witness, Baptist, Pentecostal and Bahai.

4.5.4.10 Protection Services

Hay River has a 14 member RCMP detachment, which provides service to outlying areas and nearby communities.

Figure 4.5-1 provides a comparison of the incidence of community violence and abuse, based on RCMP cases for 1994 in Hay River and three small Alberta communities. Population figures are approximate.

Hay River has the highest rate of intoxicated persons per 100 population of the NWT Diamonds Project study communities. Hay River has a number of bars, a large single population and attracts visitors from other NWT communities. Hay River also has a high rate of drug cases per 100 population for the NWT study communities.

The rate of property damage, largely break and enter and petty theft, while higher than that of larger Alberta communities, is comparable to small communities in Alberta (RCMP “G” Division 1995b and 1995c).

The town fire department is staffed entirely by volunteers and provides fire, rescue and ambulance service to the community and surrounding areas. The department also assists in the training of fire and rescue crews from surrounding communities.

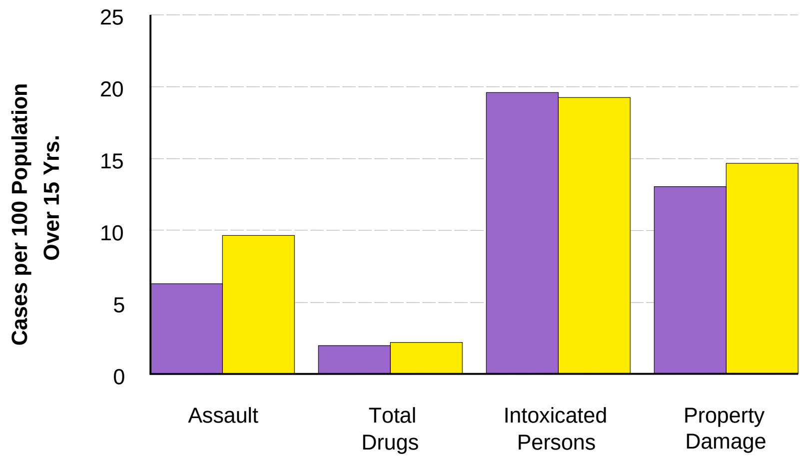
Other emergency services provided by volunteer organizations include air search and rescue, marine rescue and an emergency measures organization. The Coast Guard maintains a marine emergency base in Hay River and can provide environmental protection assistance.

The South Slave Correctional Centre, a GNWT facility, provides regional correctional services.

4.5.4.11 Commercial/Industrial

Close to 40 commercial lots, ranging in price from $6,000 and up, are available. Development has started on a recently released undeveloped commercial block in

Hay River vs. Small Alberta Communities



Hay River

Population over 15: 2,571

Small Alberta Communities (Fort Vermilion, Fort Chipewyan, Lac La Biche)

Population over 15: 1,120

NOTE: **Based on estimated population over 15 years of age, 1994.**

May not fairly represent community violence cases over a period of time.

NWT DIAMONDS PROJECT

Figure 4.5-1
RCMP Statistics for 1994—
Hay River/Small AB Comm.

Source: RCMP Statistics for 1994

the downtown area. Prices for 6,500 m^2 commercial lots downtown for sale by the town are $70,000. Serviced commercial and mixed use commercial lots elsewhere range from $20,000 to $190,000. Unserviced industrial and commercial lots range from $6,000 to $9,000. In addition, vacant commercial land is available from private owners (Hay River 1995a, 1995c).

4.5.4.12 Financial Resources

Hay River residents and businesses, through direct taxes, user fees and purchase of developed land, account for 55.5%, or $2.3 million, of the Town of Hay River revenues. Grants in lieu of taxes and transfers from other levels of government account for some 37.5%, or $1.58 million, of town revenues (Hay River 1994).

4.5.5 Capacity for Growth

The town limits extend some 32 km south along the highway. The total developed area is 7,240 ha. Since 1992, the Town of Hay River planning and zoning department has been staffed for only six months of the year. For the other six months, planning matters are the responsibility of the Director of Public Works and Planning. With increased development, there is a need to review staffing in this area. Commercial development is projected at $5 million annually for the next few years and residential development at $2.5 million annually on existing and newly developed lots (Hay River 1995a). Tables 4.5-15, 4.5-16 and 4.5-17 list municipal facilities, capacity and percent usage of these facilities.

Table 4.5-15
Hay River
Municipal Facilities/Capacity

	Capacity	Usage
Medical		
H.H. Williams Hospital	50 beds	39.4%
Public Safety	**Manpower**	
Firefighting	30 Volunteers	
Ambulance	(Fire department)	
Police - RCMP	14 Full time	

Source: Hay River 1995a.

4.5.5.1 Work Force

Hay River's total population is expected to reach 3,500 in the year 2001 (NWT Bureau of Statistics 1993). The business community expects that the work force will expand to meet the demand as a result of importing skilled workers from the

Table 4.5-16
Hay River
Municipal Facilities/Capacity

	Capacity	Usage	Notes
Schools			
Princess Alexandra	264	103%	
Harry Camsel	264	80%	Upgrade 1995-1996
Diamond Jenness	410	100%	Upgrade 1996-1997

Source: Hay River 1995a.

Table 4.5-17
Hay River
Municipal Facilities/Capacity

	Capacity	Usage
Community Services		
Ben Sieverts Arena	550	45 - 90%
Community Hall	200	25 - 35%
Swimming Pool	75	35 - 50%
Fitness Centre	15	75%
Curling Rink	3 Sheets	60 - 75%
(NWT) Public Library		24,000/a
Outdoor Facilities	Replacement	
6 Ball Diamonds	Replacement planned - 1 (1996?)	75 - 80%
Track & Field Facilities	440 metre track	
Golf Club	9 hole - 230 members	75 - 80%
Ski Club	10 km trails	35 - 50%
Beach	(Territorial Park)	50%
Boat Launch	(Territorial Park)	50%
Tennis Court	One	50%
Other Facilities; Bowling	5 lanes	70%

Source: Hay River 1995a.

south. An additional 425 students will have reached work force age by the year 2001.

4.5.5.2 Social/Leadership Resources

The town has a small but experienced group of long-term citizens who provide leadership. Hay River also benefits from the relatively large number of Northerners who have retired here after many years of northern experience. These include people with experience in both mining and oil and gas development projects.

4.5.6 Community Attitudes

The Hay River business community has received considerable benefit from the NWT Diamonds Project to date because of the variety of services available. This has resulted in a very favourable attitude to diamond development, including support from the Chamber of Commerce. Town taxpayers are looking forward to increased development and a broader tax base for the town (Goens 1995).

A “can do” approach typifies business management in Hay River. Outward looking and well-informed about mining development and potential development elsewhere in the western Arctic, Hay River businesses are aggressive in their pursuit of opportunities.

4.6 Competing/Complementary Projects in the NWT

As of spring, 1995, there were no projects in the final planning stages in the Northwest Territories of the magnitude of the NWT Diamonds Project.

The largest projects under consideration include a handful of gold prospects in the general area of Lupin Mine and three potential base metals prospects in the same general area. All these projects depend on stable or increasing prices for the minerals, which in turn are dependent on world demand. The base metal projects also depend on the development of infrastructure – roads, and possibly a port, to ship the product to overseas markets.

The only large development that has reached the feasibility stage, Izok Lake, was put on hold indefinitely.

The smaller gold mines, if proved feasible in the next year or two, might go into production, with potential employment in the study region of between 100 and 300 persons/per year, depending on the number of mines that open.

Two hydro development projects with short-term employment potential have been proposed. The $35 million Snare Cascades project will employ up to 130 in construction in 1995/1996. A project to develop hydro potential near Wha Ti could also employ some 130 persons during the construction period, but this project is not currently in the feasibility stage.

Elsewhere in the NWT, the Prairie Creek development in the Mackenzie Mountains is almost complete. If given the go-ahead, the mine would require a road and operating crew and would provide some employment opportunities for Northern residents in the mine region.

Discoveries of minerals with potential to be mined have also been recorded in the Keewatin area, and exploration continues in the Arctic Islands, but these projects, even if they go ahead, would not have a large impact on the western part of the Northwest Territories (Lutra 1993; NWT Chamber of Mines 1994; Royal Oak Mines 1995; Hoeffer 1995).

4.7 No Development Scenario

Residents of the Northwest Territories are facing cutbacks in GNWT programs as a result of rising costs and federal cutbacks. Expenditures in the early 1990s have been growing at a rate of 4.4%, while revenues to the territorial government from the federal government are actually shrinking. This has resulted in an anticipated deficit in 1996 of some $38 million.

Approximately 85% of GNWT funding comes from the federal government. A large part of this funding is tied to a formula financing arrangement, which will be trimmed by the federal government an average of $50 million per year for four years starting in 1996/1997. The territorial government anticipates that more cuts in federal support will be announced (NWT Financial Management Board Secretariat 1995).

The territorial government is faced with a fast-growing population, difficult health problems, unpredictable economic conditions and a growing adult population with increasing expectations of employment. These four conditions put considerable pressure on government spending in the areas of education, health, housing and social assistance.

In addition to imperative cutbacks in spending, the GNWT is reviewing its options to increase revenues. Suggestions include increases in personal taxes, corporate taxes and sales taxes. At present, the territorial government raises some 12% of its revenues through taxation. However, because of the small size of the population and the limited number of residents who actually have jobs, few of the taxation options by themselves would make up for the anticipated cuts in federal funding. Compounding the problem, the formula financing arrangement currently in place reduces the federal contribution to the NWT by approximately $1.30 for each additional tax dollar collected by the NWT under the current tax regime.

As noted elsewhere in this report, many sectors of the NWT economy are dependent on government spending. These sectors will be affected by pending government cutbacks. Potential tax revenue options would also be limited by decreases in government spending, which contributes significantly to personal income in the NWT, unless there is a corresponding increase in economic activity.

The mining industry and the oil and gas industry are the largest revenue producers and private sector employers in the NWT. Prices of gold and base metals have declined in the early 1990s worldwide. Prices of fuel, also subject to world markets, are equally uncertain. However, even at the current low prices, sales of these products are equal to half the NWT government budget each year. Expenditures on employment and goods and services help support more than one sector of the economy. Growth in either or both of these industries offers the greatest potential to assist in maintaining lifestyles and standards of living by providing employment and income to NWT residents and tax revenues to the territorial government.

The settlement of outstanding Aboriginal claims in the NWT Diamonds Project area offers the potential of a cash infusion in the future to encourage more economic activity. However, the claims are still under discussion. Furthermore, there is no guarantee that all or even part of any cash settlement or royalty would actually be spent in the Northwest Territories.

4.8 Archaeology

Historic or archaeological sites have been identified as a valued ecosystem component. Sites with cultural deposits are considered sacred by Aboriginal communities. The cultural information provided by the sites is also of great interest to archaeologists, anthropologists and the general public.

The archaeological reconnaissance conducted for the NWT Diamonds Project was the first detailed archaeological investigation carried out in this area. The data collected have contributed to the understanding of archaeological resources in this region of the Northwest Territories.

The majority of archaeological field studies for the NWT Diamonds Project were undertaken in 1994. Six survey areas in the main exploration and development areas were assessed for archaeological significance. Previous research in surrounding areas, consultation with local communities and Prince of Wales Northern Heritage Centre staff provided information to supplement archaeological field work. Additional research was conducted with respect to the assessment of archaeological resources along the Lac du Sauvage esker, since this was the initial route considered to access the Misery pit. An alternative route was subsequently proposed by the Operator to avoid disturbing archaeological sites and wildlife habitat.

Archaeological field research yielded 50 sites. Three sites were judged to be of high archaeological significance, representing repeatedly visited camping locations. Two sites of moderate archaeological significance represented moderately high yield, with one being a possible quarry/lithic workshop and the other having significant buried deposits. Several sites suggestive of buried cultural deposits and/or moderate yields, were assigned low-moderate significance. Most sites were assigned low archaeological significance.

4.8.1 Previous Research

Archaeological research in the western portion of the Northwest Territories was initiated by R.S. MacNeish with surveys in the upper Mackenzie drainage Great Slave Lake area (1951) and the middle Mackenzie Great Bear Lake area (1953, 1955). Based on this work, MacNeish formed a tentative cultural sequence, which has since been modified. Nobel (1971) conducted a reconnaissance program in the Great Slave Lake area and adjacent vicinities, which resulted in the elaboration of the regional cultural sequence and the identification of the Talteilei tradition. Cinq-Mars (1973) and D.W. Clark (1975) investigated the western Great Bear Lake area and portions of the Mackenzie River. McGhee (1970) excavated a series of sites in the Coppermine River area (Cinq-Mars and Martjin 1981).

No archaeological investigations were conducted previously in the immediate vicinity of the NWT Diamonds Project area. Within the upper Coppermine drainage, Metcalf and Kobelka (1978) conducted a survey to the west and discovered 74 sites. Site types represented on the 76D 1:250,000 map sheet (which includes the NWT Diamonds Project study area) include lithic scatters, lithic scatters with tent rings, cairns, campsite and a lookout/quarry site. MacNeish (1951) also located two sites on this 1:250,000 map sheet; both are described as prehistoric campsites.

Further west, Wayman and Andrews (1994) recently conducted excavations near the community of Snare Lake in advance of airport construction. Over two seasons, one of seven hearths was excavated and the other six were tested or partially excavated. Excavation has suggested that the hearths represent central features within a teepee-like structure. Activity areas within the structure were apparent. Faunal remains include lake trout, walleye, willow ptarmigan, snowshoe hare, marten and caribou. Faunal analysis suggests occupation in the winter or early spring. Ethnicity of the site could not be determined, but historically this region was occupied by Yellowknives and today the modern Dogrib settlement of Snare Lake is nearby.

Archaeological investigations conducted to date suggest that occupation of the Northwest Territories extends to 7,000 or 8,000 B.P. (before present). The earliest cultural period is typified by lanceolate points and is commonly referred to as the Northern Plano tradition. Sites are commonly found on sand eskers and in blowouts. Quartzite is a commonly used lithic material. The period from approximately 6,500 to 3,500 B.P. is identified as a descendant of the Plano, but is poorly represented in the archaeological record. It has been referred to by a variety of names, including the Shield Archaic.

The appearance of a Pre-Dorset or Arctic Small Tool Tradition is believed to be associated with the cooler climatic period, postulated to be around 3,500 B.P. The tools of this tradition are smaller, thinner and well-fashioned. They are primarily made of fine-grained cherts. Point characteristics include concave bases, triangular outlines and side-notching. This is presumed to represent a distinctive caribou-adapted Paleoeskimo culture. Sites are located on sand exposures in protected bays, on sheltered points, on eskers and on islands.

The first evidence of the Taltheilei tradition was around 2,500 B.P. This tradition is assigned to the Athapaskan occupation of the Northwest Territories. Tools were commonly made of a grey siliceous shale or quartzite; specimens of chert, basalt and red slate have also been recovered. The use of native copper has been associated with this period. The Taltheilei tradition is typified by a variety of point styles, including lanceolates and side and corner-notched specimens. Both the Arctic Small Tool and Taltheilei traditions are associated with barren land and forest environments and caribou hunting (Clark 1977; Gordon 1977; Noble 1977, 1981).

4.8.2 Consultation

Dogrib and Yellowknives Dene communities have been kept informed of archaeological studies conducted around the proposed mine development site. Community meetings and discussions with elders have provided useful information regarding the cultural significance of certain land features and the importance of their conservation.

The Proponent's plans for archaeological investigations were initially presented to the Dogrib people at Rae-Edzo on March 19, 1994. While members of all four communities (Rae-Edzo, Wha Ti, Snare Lake and Rae Lakes) were invited to this meeting, most attendees were residents of Rae-Edzo.

In a subsequent meeting on May 20, the Proponent proposed that it would rename the lakes in the mine development area using Dogrib terms. A research licence was obtained for this purpose from the Science Institute of the Northwest Territories by Points West Heritage Consulting Ltd. to undertake research with the assistance of Dogrib elders. However, the licence was cancelled when community members were unavailable to participate in this research.

The Proponent presented its archaeological study plans to the Yellowknives Dene people at Dettah and N'dilo on March 21.

The proposed archaeological research was included in the Proponent's presentation at the open house meeting held in Yellowknife March 30.

The Proponent arranged for elders from the four Dogrib communities to attend a community meeting in Rae Lakes on June 21. Although the main objective was to discuss archaeological concerns around the proposed mine development site, a number of more general environmental issues were also identified. It was noted that eskers have been traditionally viewed as significant land features. Eskers are an important travel route for animals, and were a likely location for human burials, since esker materials are easier to dig than the deposits in the surrounding landscape. Burial sites were described as being surrounded by crib work or possibly covered or ringed by stones. Apparently burials were plotted on traditional land use maps, but these maps did not extend into the barren lands.

A similar community meeting was scheduled in Snare Lake, but was not attended by residents. However, two Snare Lake elders returned to Yellowknife with the Proponent's archaeologist to attend further meetings arranged with Yellowknives elders from Dettah. As Yellowknives elders were unavailable on June 22, the Snare Lake elders discussed issues related to archaeological work at the project site. Their concerns were similar to those voiced at Rae Lakes and focused largely on the importance of preserving burial sites.

On June 23, six Dogrib elders flew to the Proponent's proposed mine site. Although Yellowknives elders had been invited on the trip, they were unavailable to participate. At the request of the elders, the plane circled the area at the northeast end of Courageous Lake where there is a pocket of trees. The remains of at least one structure were evident, and this location is purported to contain a number of burials. The proposed development area is a considerable distance from this site, and no ground investigation was deemed necessary.

After a brief tour of the Koala exploration camp, two elders flew to the south end of the main esker at Lac de Gras. The elders reiterated that protection and improvement of burial sites is very important to the Dogrib. They stated that graves could be susceptible to disturbance, since esker materials are easily excavated. A rock the approximate size of those used to ring burials was examined. Evidently, oval or elongated rings of rocks were placed around burial sites. The size of the ring was dependent upon the size of the individual buried.

One of the elders stated that he used to use a dog sled to cross Lac de Gras travelling northeast/southwest in the area south of the proposed mine development area. Both elders indicated that the most preferable camping areas would be those protected from the wind. In late June, this would be on the east side of the esker. Presumably, when insects are present in warmer weather, the top of the esker or other exposed areas would be more favourable. The two elders were flown over the previous Misery road route, and over two small lakes, which they considered as unlikely camping areas.

Two more elders flew to the south end of the main esker. During that trip, a small lithic scatter was discovered on the top of the esker.

A non-technical summary report was prepared as part of the archaeological permit requirement, and was provided to each of the four Dogrib and two Yellowknives Dene (N'dilo and Dettah) communities. In addition, these Dene communities each received a copy of the full technical report (Appendix II-CI).

4.8.3 Methods

Research was conducted during intervals between mid-March to late June. Emphasis was placed on reviewing reports and documents related to archaeological sites and traditional use of the barren lands. Members of Dogrib and Yellowknives Dene communities and staff from the Prince of Wales Northern Heritage Centre provided helpful background information. Work was conducted under Northwest Territories Archaeologists Permit #94-768.

The project area was divided into six arbitrary survey areas to facilitate discussion. The first survey area comprised the previously proposed road route from Misery Lake to the vicinity of the Koala camp. The second survey area was along an extension of the Lac du Sauvage esker at the south end of Exeter Lake, the site of the first exploration camp (Norm's camp). The third survey area was the existing winter road. The fourth survey area involved the southern extension of the Airstrip esker, south of Koala camp, for which no specific development was identified. The fifth survey area included an extension of the Lac du Sauvage esker associated with two exploration camps near Falcon Lake (Falcon and Ray's camps), and the sixth survey area was the lakes associated with Koala camp and the proposed location of various mine pits, waste rock dumps, access roads and the tailings impoundment. The survey areas are shown in Figure 4.8-1.

The initial step in the field investigation was a helicopter overflight of each survey area prior to field reconnaissance. Each of the six survey areas was flown at least once. All landforms with potential archaeological sites were subsequently examined. Areas typified by low-lying and poorly drained deposits suggest low archaeological potential and were not generally subject to foot traverses unless they were on a travel route required to access an area with moderate or greater archaeological potential.

Once the crew was familiar with each of the six survey areas, ground reconnaissance was initiated for those areas suggestive of moderate or greater archaeological potential. Due to extensive exposure and the fact that the majority

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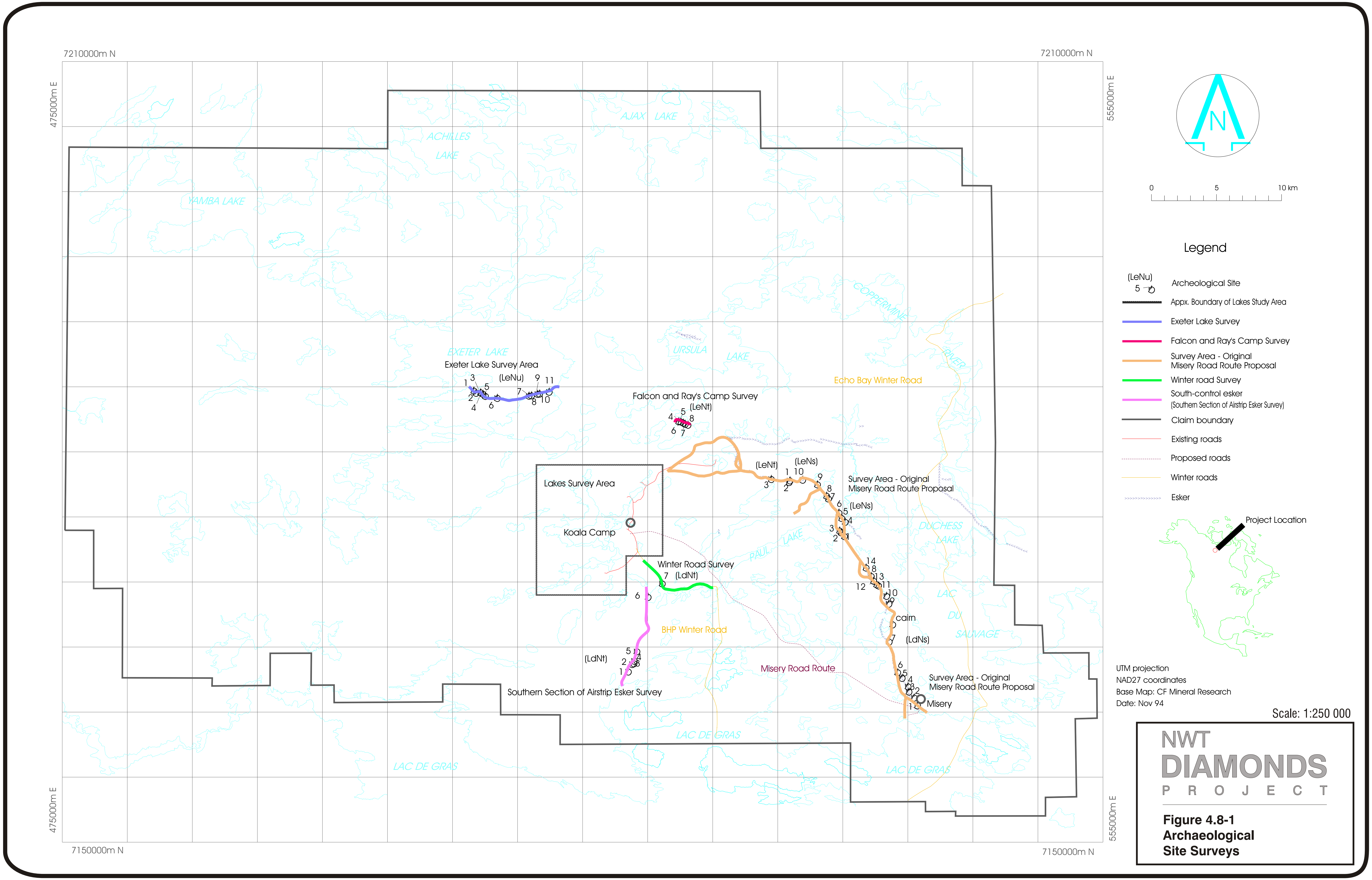

Source: Rescan

of the archaeological sites were deflating, ground reconnaissance primarily consisted of a series of foot traverses with intensive surface examination.

It should be noted that during the assessment of the previous Misery road route (and in other areas with restricted development), areas with archaeological potential that were within 50 m (or more) of an identified development were also examined. Thus, investigations were not limited to the esker, but extended to elevated landforms adjacent to lakes or other topographic features with archaeological potential. Three persons, spaced at roughly 10 to 15 m intervals (depending on vegetation, surface visibility and landform size), systematically traversed each survey area, inspecting the ground and any natural and/or artificial exposures. Areas judged to have moderate to high archaeological potential, such as level esker deposits adjacent to aquatic features, were visually examined several times. Those areas assessed as having low archaeological potential were examined less intensively or not at all.

In areas where there was vegetation, or where the possibility of soil development was noted, subsurface testing was also conducted. Since there was generally excellent exposure, this testing was generally limited to one or two shovel tests. Shovel tests assisted in the determination of the general nature, horizontal and vertical extent and integrity of the subsurface cultural deposits. These tests averaged 40 cm x 40 cm in size; depth was generally shallow, but extended to obviously sterile matrices. All deposits were excavated in rough 10 cm levels and screened through 1/8 inch (3 mm) mesh.

As there are no NWT guidelines regarding the determination of the significance of archaeological sites, archaeological significance was defined according to British Columbia guidelines. The British Columbia Archaeological Impact Assessment Guidelines (British Columbia 1992) provides definitions for archaeological sites and assigns sites significance according to ratings of low, moderate or high.

A location is defined as a site if tools, fragments of rock from tool-making or signs of occupation are found. A site is considered to be of low or low-moderate significance if it contributes little or nothing to the cultural understanding and knowledge of the pre-history of the study area and if there was little potential for buried cultural deposits. A site was ranked moderate or moderate-high if it had a potential to contribute knowledge and understanding of the pre-history of the study area. A site was considered to be highly significant if there were signs of repeated occupancy, if it was a large site, had a high potential for buried cultural deposits and if it contributed to the cultural understanding and knowledge of the pre-history of the study area. An example of a highly significant site is a repeatedly-used camp area.

Formed tools and artifacts with diagnostic potential were collected, as were all artifacts encountered during subsurface testing. In addition, during the assessment phase of the field reconnaissance, examples of lithic materials not evident in the tool sample were collected. All cultural material recovered during the surface reconnaissance and shovel testing program was recorded by site, location/test unit number and depth. After analysis and completion of the final report, these artifacts were deposited at the Canadian Museum of Civilization in Ottawa as requested in the permit.

Sites discovered during the inventory were recorded in detail using the Archaeological Survey of Canada site entry forms. Detailed maps of the sites, produced by the pace and compass method, were drawn and were included in the final report (Bussey 1994) (Appendix II-C1). Photographs were taken for future visual reference. Temporary field numbers were assigned to each of the sites. They were prefaced by BHP 94, which refers to the project and the year. In total, 34 new sites (BHP 94-1 to BHP 94-34) and 16 isolated finds (sites with a single artifact and referred to on field maps as IF) were located. Only those isolated finds that contained tools were given a number. The Archaeological Survey of Canada has provided permanent Borden numbers for each of the locations containing archaeological specimens, including isolated finds, and these permanent numbers are used in this discussion.

Data collected for the site entry forms were used in the assessment of each site. As many of the sites were small and represented by a low yield of primarily debitage, further assessment of these sites was not deemed necessary. Larger sites, which were generally those with some buried deposit potential, were revisited during the assessment phase. All sites yielding over 50 artifacts were revisited and assessed in more detail. In addition, sites that yielded unique artifacts (i.e., LeNs-3 - birch bark basket) were revisited, as were a number of the smaller sites.

A preliminary archaeological assessment of the preferred second Misery road route was conducted in late 1994 and early 1995. Since this Misery road route was proposed when archaeological field work was not possible due to snowcover, this route has been investigated through aerial photographs, review of 1:50,000 topographic maps and consultation with Prince of Wales Northern Heritage Centre staff.

4.8.4 Inventory Results

The results of fieldwork conducted for the archaeological inventory of the NWT Diamonds Project are summarized in this section. The information is described in greater detail and presented by survey area and subsection in Bussey (1994) (Appendix II-C1). The locations of recorded archaeological sites are identified in Figure 4.8-1.

The terms debitage, detritus, flakes, lithics and unworked flakes are used interchangeably in the following discussion and refer to the waste flakes that are discarded in the process of making stone tools. These specimens show no evidence of further modification. If further modification is evident, it is referred to as retouch, or the specimen is identified as a specific type of tool using standard archaeological, descriptive terminology. Flakes, modified flakes and tools are all considered to be artifacts. Diagnostic artifacts are those that are suggestive of a specific time period.

A total of 50 sites were identified (Figure 4.8-1) in the six survey areas. Twenty-seven of these sites are located on the main section of the Lac du Sauvage esker. Of these, two were assigned high archaeological significance, four were judged to be of low-moderate significance and 21 were of low significance. The other 23 are located on the esker near Ray's/Falcon camp (five sites), on the esker at Exeter Lake (the former location of Norm's exploration camp; 11 sites), on the Airstrip esker south of Koala camp toward Lac de Gras (six sites) and along the winter road (one site). One of these sites was considered to be of high archaeological significance, two were assessed as being of moderate significance and the remaining 20 sites were suggestive of low archaeological significance. No sites were found in the lakes survey area.

The majority of the archaeological sites discovered were isolated finds (16) or small to medium-sized surface lithic scatters with fewer than 50 visible flakes (21) recovered from shovel tests and surface collection (Figure 4.8-1). Nine sites contained 50 or more surface artifacts, including one that may have served as a lithic quarry and/or workshop locale and one (LeNs-5) that may have been a temporary camp site. The remaining four sites included one that yielded a unique artifact, a birch bark basket. The other three represent more frequently used or longer term camp sites. The site types discovered are comparable, in frequency, size and cultural content, to those found in adjacent areas in other studies.

A single organic artifact was discovered, and the remaining artifacts were made of various lithic materials. A birch bark basket was discovered at LeNs 3. As this organic artifact would have quickly deteriorated once removed from its environment, it was packaged and shipped to the Prince of Wales Northern Heritage Centre, where it was stabilized then transported to the Canadian Museum of Civilization. The lithic artifacts collected were submitted to the museum upon completion of analysis.

At one location on the previous Misery road route, a series of three variously shaped and sized "rock piles" were encountered. At the time, it was not known if these were natural or cultural features. Testing in the largest rock pile indicated these features were a natural result of the esker deposits eroding.

The number and distribution of the sites suggest that eskers served as travel routes during the seasonal subsistence round. Large and small archaeological sites are associated with these eskers, although the more prominent of these glacial features tend to have greater potential. Those eskers associated with medium to large-sized lakes also appear to have more potential. Similar landforms in adjacent areas should be subject to an archaeological assessment prior to any development.

As in any archaeological study, some sites could be missed as a result of survey coverage or vegetation. However, for this study area, it is unlikely that any sites, other than isolated finds or very sparse lithic scatters, were missed because of the intensive ground examination and the extensive exposure as a result of wind or water deflation. One expected site type, burials, was not represented in the archaeological inventory. Any burials associated with rings of rock or rock mounds would have been found, but it is possible that there could be burials that are not identified in this manner. With no surface features, the identification of such locations is next to impossible. However, with the amount of exposure evident in much of the esker, there seems to be relatively low potential for burial sites to be found. In the event that burials are encountered during construction, any excavation work will be temporarily suspended and the Prince of Wales Northern Heritage Centre will be contacted.

4.8.4.1 Previous Misery Road Route Survey Area

This survey area consists of the previous Misery road route, a narrow corridor along the Lac du Sauvage esker that extends from Pointe de Misère on Lac de Gras, north and west of Panda Lake near Koala camp. The western portion of this route leaves the esker to cross a poorly drained tundra environment with low archaeological potential. Portions of this tundra environment were traversed and all portions were flown. Landforms with some archaeological potential were examined on the ground. Any landforms in the vicinity that were suggestive of moderate to high potential for archaeological sites were included in the ground reconnaissance. The corridor examined was often larger than the area previously proposed for road construction.

The large esker upon which the majority of the previously proposed Misery road is situated is comprised of varying amounts of generally eroding deposits. In places, the esker rises as high as 60 m above the surrounding topography, which is typified by numerous lakes. Other portions of the esker have been entirely eroded, leaving low-lying areas dominated by tundra vegetation or lakes. These gaps range in size and can be 100 m or greater in length. The width of the esker varies from as narrow as 3 m to well over 100 m. Generally, the esker deposits are comprised of loose sand with varying amounts of small and medium-size gravels and rock, overlying a homogeneous yellowish-brown fluvial sand. Small patches of the esker have developed a peaty soil, and even fewer areas contain pockets of aeolian deposits. Deflation has occurred in extensive areas and has resulted in the exposure of archaeological sites, and may have buried other such resources. Deflation may have resulted in the mixing of archaeological components and, since no diagnostic artifacts were encountered, it is not possible to identify time periods, although the majority of artifacts are represented by lithic artifacts and therefore are presumed to represent prehistoric use of the study area. Two possible exceptions are LeNs-3 (birch bark basket) and LdNs-8 (stone tent rings).

Due to the possible use of esker deposits for road construction, both the esker and the proposed route were subject to ground reconnaissance. Two trunk roads that lead to future possible development areas were also examined. No archaeological resources were located on these two routes. Finally, in two localized areas, two possible route alternatives were identified. In both cases, significant archaeological sites were found on one of these two alternatives.

The previous Misery access road route survey area yielded 27 archaeological sites, seven of which were isolated finds. The seven isolated finds were assigned low archaeological significance. Fourteen of the 27 other recorded sites were assigned low archaeological significance, four were assigned low-moderate archaeological significance and two were assigned high archaeological significance. Also noted were two possible caches and a possible signal rock. As no definitive evidence of human use of these three localities was discovered, no further assessment was conducted.

4.8.4.2 Exeter Lake Survey Area

The Exeter Lake survey area is approximately 10 km northwest of Koala camp. This is the location of the original exploration camp, known as Norm's camp. Development includes a small camp, an airstrip and informally used roads. During the archaeological assessment, an esker and associated landforms were examined. This esker is evident at the south end of Exeter Lake and extends east and west of Norm's camp. Norm's camp has been abandoned and no new development was identified at the time the archaeological field investigation was conducted.

The large, broad esker at the southeastern end of Exeter Lake is approximately 6 km long and appears to be an extension of the Lac du Sauvage esker. The western half of the esker at Exeter Lake separates the main body of the lake from a secondary lake to the south. Examination did not extend east of the creek between these two lakes, but there may be archaeological potential elsewhere in this vicinity. Norm's camp is located south of the esker, near its mid-point. Eleven sites were identified in this survey area, of which four were isolated finds.

4.8.4.3 Winter Road Survey Area

The route used as a winter road in past seasons was also examined for archaeological resources. The majority of this route is located in bogs or on undulating tundra that is interspersed with small and medium-sized lakes. These landforms have little potential for archaeological resources and were flown, but were not consistently traversed. However, a portion of the winter road is located on an esker between Lac de Gras and Koala camp. The southern 4 km of this road is on a small esker-like landform that extends west of Lac de Gras through a series of small lakes. At this point, the smaller esker connects with a medium-sized esker that runs northwest for approximately 2.5 km. Most of the stretch from Lac de Gras west is quite low and boggy and was not investigated on foot, but some locales were examined. The area northwest along the well-defined esker was subject to a series of foot traverses. A single unworked white quartz flake identified as an isolated find, LdNt-7, was recorded and left *in situ*. LdNt-7 is assessed as having low archaeological significance.

4.8.4.4 Southern Section of Airstrip Esker Survey Area

This survey area consists of a large esker located south and west of the winter road. It begins approximately 1 km north of Lac de Gras and extends 8 km to the north. Six prehistoric archaeological sites, including two isolated finds, were recorded in this survey area.

4.8.4.5 Falcon and Ray's Camps Survey Area

Two exploration camps, Falcon and Ray's camps, are situated on an esker that separates a large lake (to the north) and a medium-sized lake (to the south). As the camps are already established, some disturbance has occurred. However, as Ray's camp is a mobile camp, the disturbance associated with it is considerably less. This survey area is located north and east of Koala camp and the lakes survey area. The area examined during the archaeological reconnaissance was a relatively continuous esker. Field investigations were initiated at the western end of the medium-sized lake and continued for a distance of approximately 2 km. It should be noted that there are landforms in the surrounding area that were also judged to have archaeological potential, but they were outside of this survey area. Three small prehistoric sites (LeNt 5 to 7) and two isolated finds (LeNt 4 and 8) were located.

4.8.4.6 Lakes Survey Area

The lakes survey area is located in a low-lying and undulating tundra environment characterized by numerous small and medium-sized lakes. Higher landforms tend to consist of limited areas of exposed rubbly, shield rock and small esker remnants. Peat-like soils are dominant, and well-drained landforms with potential for archaeological sites are very limited. A majority of the development associated with the NWT Diamonds Project is centred in this survey area. Included here are the proposed mine sites, waste disposal areas, existing and proposed camp and construction sites, process plant, airstrip, a series of access roads and the tailings impoundment (Long Lake). No archaeological sites were discovered in this area, and little archaeological potential is predicted in surrounding areas that were not subject to ground reconnaissance.

Five of the lakes in this area were examined on the ground during the 1994 field investigations, and the remainder of the area was viewed numerous times during helicopter overflights. Landforms surrounding Panda, Koala, Leslie and Fox lakes were subject to systematic foot traverses. More intensive examination was conducted on better-drained and better-defined landforms associated with these lakes. No archaeological sites were found. The negative results from the investigation of these lakes prompted a less intensive examination of Long Lake.

Helicopter access was used to visit all landforms on Long Lake that were within the identified impact zone (increased water level and tailings disposal areas) and were suggestive of archaeological potential. The landforms assessed were those that were elevated slightly above Long Lake and were typified by good drainage and bedrock outcrops. No archaeological sites were located.

4.8.4.7 Misery Road Route

The majority of the Misery road route passes through areas assessed as having low archaeological potential. These areas are inland from major lakes on rugged terrain that does not provide a logical travel route and does not contain well-defined, elevated terrain units that would be suitable for human use. However, other portions of this route are judged to have sufficient archaeological potential to justify field investigation. The greatest potential is evident in the vicinity of Misery Lake and Lac de Gras, and, particularly, in the area between Lac de Gras and Paul Lake; the former has already seen some examination, with negative results. The area previously examined was a narrow corridor associated with a spur of the previous road route, and thus more detailed investigation is justified. In light of the 1994 study in this area, the esker north of Paul Lake also has sufficient archaeological potential to justify field investigation.

Another area with archaeological potential was identified in discussions with Prince of Wales Northern Heritage Centre staff. There is a strong possibility that Paul Lake served as part of a canoe route between Lac de Gras and Duchess Lake; hence it is likely that a portage route could be located between Paul and Duchess lakes. This possibility is enhanced by the presence of a large site on the western side of Duchess Lake. The area between these two lakes has potential to yield additional sites. No development is proposed in this area.

Site types that could be encountered include small to large lithic scatters, caches, possible camping locations (including those containing tent rings), burials and isolated finds. It is predicted that the majority of these sites would be located on elevated, well-drained land associated with the larger lakes. Treaty 8 elders have indicated that there are sacred sites along the Misery Road route. It is predicted that the majority of sites along this route would be small. However, there is some potential for a camp associated with the area between Lac de Gras and Paul Lake.

Summary

The majority of the sites located in the six survey areas are suggestive of short-term use. Most are suggestive of a single activity, such as the making or modification of a stone tool. However, at least three are suggestive of repeated, and possibly, longer term use; none is suggestive of a permanent occupation. No evidence of stratified deposits was encountered. Exposure was generally excellent due to deflation and, as a result, intensive examination of surface artifacts was possible. Specimens suggestive of formed tools were collected as a reference sample. Twenty-nine tools were collected from 15 sites, with an average of two tools per site (Table 4.8-1). Ten sites yielded one tool each, three sites yielded three tools each, one site yielded four tools and one site yielded six tools. As 50 new sites were recorded, the tool yield is not very high, but it should be acknowledged that unformed tools such as retouched flakes were not systematically collected.

The low yield of tools may be a result of their curative value or may be indicative of the possibility that rapidly made and minimally worked tools were sufficient for most activities conducted in this area. The presence of a number of bifaces presumed to represent projectile points suggests hunting was conducted, which is not surprising considering that caribou migrate through this area. Other tools are suggestive of use as knives, which could be used for a variety of purposes, including the processing of the harvest from hunting expeditions. A number of large and heavy duty tools believed to have been used for chopping or similar activities may also have been used in association with hunting. However, many of these tools are multipurpose and thus specific functions are not easily identified. Although it is presumed that hunting was conducted, other activities, such as food preparation, fishing, berry gathering, etc., could also have been undertaken. At two sites, hearths were encountered. Whether these served as a source of warmth, were used to prepare food for immediate consumption or were smudges is unknown. The primary function of one site, LdNt-5, appears to have been the procurement and/or modification of quartz for stone tools (Table 4.8-2).

The majority of the specimens collected represent unformed tools, formed tools that were broken or tool types that occur throughout time. It is impossible to compare these tools to specimens from specific time periods or cultural traditions.

Table 4.8-1
Inventory of Tools Recovered During the
1994 BHP Archaeological Reconnaissance

Artifact #	Location	Artifact Type	Comments, Dimensions, Weight
LdNs-4:1	Surface	Formed Biface	A large, rectangular, fine-grained basalt biface; displays continuous bifacial retouch along all margins and on both faces; L=21.1 cm; W=5.7 cm; Th=1.5 cm; Wt=126.3 g.
LdNs-6:1	Surface	Spall	A large, ovate, metamorphic spall chopper; displays heavy, crude unifacial retouch along one margin; L=12.8 cm; W=9.6 cm; Th=2.5 cm; Wt=471.1 g.
LdNs-7:1	Surface	Unformed Biface	A medium-sized, irregularly shaped, coarse-grained greyish-white quartz fragment; displays discontinuous, marginal bifacial retouch; L=4.2 cm W=3.4 cm; Th=1.2 cm; Wt 15.0 g.
LdNs-10:1	Surface	Unformed Biface	A medium-sized, pentagonal, grey quartz fragment; displays partial bifacial retouch; L=2.6 cm; W=2.2 cm; Th=0.9 cm; Wt=7.0 g.
LdNs 11:1	*S.T. #1 (20-30 cm b.s.)	Unformed Biface	A medium-sized, trapezoidal, grey quartz fragment; displays unifacial retouch along one margin; L=2.8 cm; W=1.7 cm; Th=0.8 cm; Wt=4.1 g.
LdNs-12:1	Surface	Formed Biface	A medium-sized, trapezoidal, clear quartz formed biface fragment; displays continuous and extensive bifacial retouch; broken transversely; L=3.3 cm; W=3.0 cm; Th=1.0 cm; Wt=8.4 g.
LeNs-1:1	Surface	Formed Biface	A medium-large, trapezoidal, grey quartz fragment; displays steep continuous unifacial retouch along two margins; L=5.7 cm; W=3.9 cm; Th= 1.4 cm; Wt=26.8 g.
LeNs-1:2	Surface	Unformed Biface	A medium-sized, rhomboidal, grey quartz fragment; displays discontinuous unifacial retouch along one margin; L=3.5 cm; W=3.1 cm; Th=1.4 cm; Wt=11.7 g.
LeNs-3:1	Surface	Birch Bark Basket	Almost complete basket constructed of birch bark; found in two large pieces (26 cm x 15 cm, and 26 cm x 7 cm) with stitch holes; nine additional fragments form strips that also have stitch holes (all are 1.5 cm wide and lengths are: 7 cm, 7.5 cm, 8 cm, 11 cm, 11 cm, 18.5 cm, 19 cm, 29 cm and 37 cm).

(continued)

Table 4.8-1 (continued)
Inventory of Tools Recovered During the
1994 BHP Archaeological Reconnaissance

Artifact #	Location	Artifact Type	Comments, Dimensions, Weight
LeNs-4:1	Surface	Formed Biface	A large, ovate, grey quartz cutting/chopping tool; displays crude, continuous bifacial retouch along two margins; L=11.9 cm; W=6.5 cm; Th=2.8 cm; Wt=280.5 g.
LeNs-4:2	Surface	Formed Biface	A small, white chert formed biface fragment, possibly the base of a stemmed projectile point base; displays fine continuous bifacial retouch; L=1.6 cm; W=1.1 cm; Th=0.3 cm; Wt=0.6 g.
LeNs-4:3	Surface	Unformed Biface	A medium-sized, irregularly-shaped, grey banded chert flake; displays partial, marginal retouch along gone margin; L=3.38 cm; W=2.57 cm; Th=0.55 cm; Wt=4.95 g.
LeNs-5:1	Surface	Formed Biface	A medium-sized, white chert shouldered and stemmed projectile point base; displays continuous bifacial retouch along both lateral margins and extensive retouch on one face; basal portion; broken transversely; distal portion missing; L=3.18 cm; W(shoulder)=2.46 cm; W(neck)=1.72 cm; Th=0.54 cm; Wt=4.8 g.
LeNs-9:1	Surface	Formed Biface	A moderately large, ovate, greyish-white quartz biface fragment; displays continuous bifacial retouch; end missing; L=5.3 cm; W=4.2 cm; Th=1.4 cm; Wt=32.3 g.
LeNs-9:2	Surface	Formed Biface	A medium-sized, parabolic-shaped greyish-black shale biface fragment; displays discontinuous bifacial retouch; possible grinding; L=3.3 cm; W=2.8 cm; Th=0.6 cm; Wt=7.1 g.
LeNs-9:3	Surface	Unformed Biface	A medium-sized, trapezoidal, coarse-grained white chert fragment; displays continuous unifacial use along one margin; L=2.5 cm; W=2.3 cm; Th=0.9 cm; Wt=5.8 g.
LeNs-9:4	Surface	Formed Biface	A medium-sized, triangular, white quartz biface fragment; displays continuous bifacial retouch on intact lateral edge; distal-lateral portion; broken L=2.7 cm; W=2.1 cm; Th=0.7 cm; Wt=3.6 g.
LeNs-9.5	Surface	Formed Biface	A medium-sized, triangular, greyish white quartz biface preform fragment; displays continuous bifacial retouch; broken transversely; L=3.6 cm; W=2.2 cm; Th=1.3 cm; Wt.=9.7 g.

(continued)

Table 4.8-1 (continued)
Inventory of Tools Recovered During the
1994 BHP Archaeological Reconnaissance

Artifact #	Location	Artifact Type	Comments, Dimensions, Weight
LeNs-9.6	Surface	Formed Biface	A large ovate, grey biface; displays continuous bifacial retouch on all edges and both faces; L=9.4 cm; W=5.9 cm; Th=1.8 cm; Wt=99.5 g.
LeNu-11:1	Surface	Formed Biface	A medium-large, crescentic, banded grey quartz biface fragment; displays discontinuous bifacial retouch with extensive retouch on one face; broken transversely; L=5.9 cm; W=4.0 cm; Th=2.0 cm; Wt.=42.0 g.
LeNu-11:2	Surface	Formed Biface	A medium-sized, rhomboidal, greyish-white quartz biface fragment; displays continuous bifacial retouch along one margin; L=3.9 cm; W=2.1 cm; Th=1.0 cm; Wt=7.0 g.
LeNu-11:3	Surface	Unformed Biface	A medium-sized, irregularly-shaped, greyish-white quartz unifacial fragment; displays discontinuous, unifacial retouch along one margin; L=3.7 cm; W=3.3 cm; Th=1.1 cm; Wt=14.6 g.
LeNu-11:4	Surface	Formed Biface	A small, rhomboidal, white chert uniface; scraper; displays continuous, fine, steep unifacial retouch along two margins and one end; L=2.8 cm; W=1.7 cm; Th=0.6 cm; Wt=3.6 g.
LdNt-5:1	*S.T. #1 (0-10 cm b.s.)	Core	A large, irregularly-shaped, grey quartz, possible core; displays flake scars and shatter planes; L=11.1 cm; W=7.6 cm; Th=3.2 cm; Wt=294.6 g.
LdNt-6:1	Surface	Formed Uniface	A medium-sized, tear-shaped, grey quartz uniface; scraper; displays continuous steep unifacial retouch along one margin; L=4.7 cm; W=3.2 cm; Th=1.2 cm; Wt=19.7 g.
LdNt-6:2	Surface	Unformed Uniface	A medium-sized, pentagonal, white quartz uniface fragment; displays discontinuous, moderately steep, unifacial retouch along one margin and discontinuous marginal retouch along one edge; L=3.5 cm; W=2.8 cm; Th=0.9 cm; Wt=9.8 g.
LdNt-6:3	Surface	Unformed Biface	A medium-sized, trapezoidal, white quartz biface fragment; displays discontinuous bifacial retouch on one lateral edge; L=2.8 cm; W=2.8 cm; Th=0.8 cm; Wt=5.6 g.

(continued)

Table 4.8-1 (completed)
Inventory of Tools Recovered During the
1994 BHP Archaeological Reconnaissance

Artifact #	Location	Artifact Type	Comments, Dimensions, Weight
LeNt 7:1	Surface	Unformed Biface	A medium-large, trapezoidal, grey quartz biface fragment; displays discontinuous bifacial retouch on one margin and discontinuous unifacial retouch on one margin; L=5.2 cm; W=4.3 cm; Th=1.5 cm; Wt=32.8 g.
LeNt-8:1	Surface	Formed Biface	A medium-sized, triangular, clear quartz biface end fragment; displays fine, continuous and extensive bifacial retouch; broken transversely; L=3.4 cm; W=2.2 cm; Th=0.8 cm; Wt=7.65 g.

* Shovel Test.
Source: Bussey 1994.

Table 4.8-2
Inventory of Lithic Waste Flakes During the 1994 BHP
Archaeological Reconnaissance

	Size Range*					Total	Total	Materials
Provenience	1	2	3	4	5	Frequency	Weight	Present
LdNs 7								
S.T. #1 (0-10 cm DBS)		1				1	1.7 g	shale
Surface				3	1	4	11.2 g	shale
LdNt 5								
S.T. #1	6	46	19	15	4	90	158.3 g	grey quartz
LeNu 4								
Surface				1		1	17.25 g	rose quartz

* Size Range: 1 = 0-5 mm, 2 = 6-10 mm, 3 = 1-2 cm, 4 = 2-4 cm, 5 = 4-6 cm.
Source: Bussey 1994.

Two tools, one complete rectangular biface of basalt from LdNs-4 and one broken shouldered and stemmed biface from LeNs-5, are similar to specimens associated with the Taltheilei traditions. This tradition is first evidenced around 2,500 B.P. However, these tools were found on the surface of two different sites at some distance from one another and represent too small a sample for a definitive statement on cultural associations. It is possible that two sites, LeNs-3 (birch bark basket) and LdNs-8 (stone tent rings), could have been utilized relatively recently.

However, the lack of supporting data (no artifacts suggestive of prehistoric, protohistoric or historic occupations were discovered) and the fact that the basket could have been preserved for a considerable period of time due to weather conditions make it impossible to assign these sites to a specific time period.

With the exception of the birch bark basket the artifacts encountered during the inventory and impact assessment were made of stone. Quartz is the dominant lithic in the artifact sample viewed and collected, although other materials are represented, including a very fine grained basalt, a variety of cherts and shale. Quartz occurs naturally in the esker deposits and its high frequency is not unexpected.